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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
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(ENGLISH EDITION)

[625. 17]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

13th SESSION (PARIS, 1937).

QUESTION III.

Methodical and periodical maintenance of : 1. metal bridges; 2. signals; 3. metal supports carrying the contact wire on electric railways.

Organisation. — Working methods. — Materials used.

REPORT

(Great Britain, Dominions and Colonies, America, China and Japan),

by Wm. A. FRASER,
Engineer (Scotland), London & North Eastern Railway.

This interesting question has not previously been considered by the Association; consequently no previous reports on the subject, to which reference could be made, are available.

Thirty-eight Administrations replied to the questionnaire, including the Canadian Pacific and Canadian National Railways who were good enough to supply information although not members of the Association.

The total route mileage of the Administrations who replied is 158 369. In a few cases two or three different gauges comprise the route mileage of an Administration.

The countries, represented by the Administrations who replied, are as follows : Great Britain, Northern Ireland, Irish Free State, India, Burma, Ceylon, Iraq, Kenya, Uganda, Nigeria, Sudan, South Africa, New Zealand, Manchukuo, Japan, United States of America, Canada, Argentine and Brazil.

In a few cases two Administrations replied jointly to the questionnaire; consequently a single reference to the Bengal and North Western Railway of India also refers to the Rohilkund & Kumaon Railway, the Pennsylvania Railroad to the Long Island Railroad, and the Buenos Aires Great Southern Railway to the Buenos Aires Western Railway.

1. — METAL BRIDGES.

Organisation.

It is evident that the Chief Civil Engineer in most cases is responsible for new construction and maintenance work, but one or two exceptions have to be noted. In New Zealand the Chief Engineer is responsible mainly for maintenance, while the Japanese Government Railways utilise a Chief Engineer for the improvement and maintenance of working lines, and another Chief Engineer for new construction. In the U. S. A. the practice is not uniform. In the case of two Administrations, the Delaware & Hudson, and Reading, the Chief Engineer is responsible for new construction work only, but not for maintenance work, except in an advisory capacity in the latter Administration. A similar arrangement applies to the Canadian Pacific and Canadian National Railways. With the latter Railway, probably due to the large route mileage, e.g. 22 559, two Chief Engineers, one for maintenance and improvement of operated lines, the other for new construction, are found necessary, under whom three Regional Chief Engineers function in Canada, and two Regional Chief Engineers in the U. S. A. responsible for the equivalent of two Regions each composed of a constituent Company operating in the U. S. A. These Regional Chief Engineers appear to function in much the same manner as the Chief Engineer of a smaller Administration, being responsible for both maintenance and new construction work. A partial analogy to this system obtains in the London & North Eastern Railway, whose system is divided into three Areas, each under a Chief Engineer entirely responsible for both maintenance and new construction work.

Only in a few cases are there distinctly separate maintenance organisations, one of these being the South African Railways & Harbours where the maintenance work is carried out under the supervision of System Managers. In the case of the Japanese Government Railways, both the Director of the Bureau of Maintenance and Improvements and the Director of the Bureau of Construction are responsible direct to the Minister of Railways. The Chief Engineer in charge of the line of the Rio Grande do Sul Railway of Brazil deals only with maintenance work, the new construction work being a separate branch of the Railway Administration.

In all the systems the total mileage is divided up to form Divisions or Districts for maintenance purposes. The route mileage of these divisions or districts varies according to the Administration concerned, generally depending upon the locality and density of traffic carried. The Districts in the Administrations of Great Britain (excluding the London Passenger Transport Board) range from 345 to 377 route miles; of Ireland from 276 to 525 route miles; of India and Burma from 200 to 1 000 route miles, but a special case is the Bombay Electrified Division which is only 194 miles in length, presumably due to heavy traffic. In Iraq two Districts suffice, one comprising both metre and standard gauge, amounting to 356 miles and the other metre gauge only, 375 miles in length. In the case of the Nigerian Railway the system was formerly divided into three Divisions, each with a Division Engineer, and Section Engineers, each in charge of approximately 190 miles, but due to shortage of staff this arrangement has been abandoned, the Section Engineers now reporting direct to the Chief Engineer, the former Division Engineers assisting the Chief Engineer. In Africa the Districts or Sections vary from a minimum of 190 miles in the Nigerian Railway, to 811 miles in the Kenya & Uganda Railways & Harbours. The average figures for the New Zealand Government Railways, South Manchuria Railway and Japanese Government Railways are 556, 350 and 245 miles respectively. In the U. S. A. this figure ranges from 209 to 634 miles, but the Canadian Pacific Railway Districts range from 1 000 to 3 500 miles, being usually confined to the mileage in one province. Each Region of the Canadian National Railways is divided into Districts (average route mileage 2 050, track mileage 2 900) in charge of a District Engineer, and sub-divided into Divisions (average route mileage 580, track mileage 800) with a Superintendent in charge. More close agreement with the general average mileage is reached by the Argentine Administrations, where the average figure ranges from 351 to 412 route miles. The average length of the Rio Grande do Sul Railway Districts is 267 miles. In practically all cases the Districts, the Divisional or the Sectional Engineer is responsible for the maintenance of permanent way and structures, including metal bridges, but metal bridges are excluded in the cases of the Ceylon Government Railway, the Delaware & Hudson Railroad (U. S. A.), and the Rio Grande do Sul Railway (Brazil).

It is the usual practice, so far as Great Britain and Ireland are concerned, to sub-divide a district into Sections, each under an Inspector responsible to the District Engineer. The Railways of India, Burma, Iraq, Africa, Argentine and Brazil adopt a similar practice, but in a few cases an Assistant or Resident Engineer, instead of an Inspector, is in charge of these Sections. In the case of the New Zealand Government Railways the District is not further sub-divided, but the Japanese Government Railways and the South Manchuria Railway do sub-divide their Districts. In the U. S. A. the division is sub-divided for track maintenance purposes only. In the case of the Canadian Pacific Railway, no further sub-division takes place, but the Canadian National Railways have a rather unique organisation in that each Region is divided into operating Districts with a Chief Superintendent in charge, to whom, and the Regional Chief Engineer, the District Engineer reports on questions involving maintenance, each district being further divided into divisions under the charge of a Superintendent.

In certain instances it is not clear if this sub-division affects the maintenance of metal bridges, or if it is only concerned with the maintenance of permanent way.

Inspection of bridges.

In most cases Inspectors normally concerned with permanent way work are expected to report any defects observed in metal bridges, although not generally responsible for detailed examination.

Considerable diversity of practice exists so far as special Inspectors of metal bridges are concerned. In Britain metal bridges are generally inspected only as part of an Engineer's or Inspector's duties, but in certain cases there are special Bridge Examiners who work under the District Inspector. In the case of the London & North Eastern Railway and Great Northern Railway of Ireland, each district has a Bridge Inspector or Examiner. The London Midland & Scottish Railway metal bridges are inspected by the District Works Inspector or his Foreman, while the Great Western Railway put definite responsibility on the Permanent Way Inspector for bridge inspection, supplemented by inspection at fixed intervals by the Inspector of Bridges. A similar arrangement exists on the Great Southern Railway of Ireland. The practice in India is more diverse. The Bengal Nagpur Railway has one Bridge Inspector to each District, while the Bombay Baroda & Central India Railway employs no special staff, the work being done by the Assistant Engineers and inspectors. In Ceylon the Bridge Inspector is responsible to the Chief Civil Engineer. The North Western Railway of India Bridge Inspectors work under Executive Bridge Engineers who are responsible to the Chief Engineer, their inspection being additional to that carried out by the Divisional Inspector of Works. In Burma two Bridge Inspectors are attached to the Bridge Department of the Head Office, but additional and more frequent inspections are carried out by the permanent way Inspector. The Kenya & Uganda and the Nigerian Railways have Bridge Inspectors who are responsible respectively to the District and Chief Engineers, but the South African Railways & Harbours, and Sudan Railways employ no special metal bridge inspection staff, this arrangement applying also to Administrations in New Zealand, Manchukuo and Japan, in these cases the general Works Staff undertaking this duty. The Bridge Inspectors in the U. S. A. and on the Canadian Pacific Railway generally work under the Bridge Engineers, who are responsible to the Chief Engineers, and carry out inspection of all types of bridges, a condition which may apply to other Administrations. In the case of the Canadian National Railways a very complete cycle of inspection is carried out for which the Division Engineer and his Bridge and Building Master are normally responsible, District and Regional Officers making an annual inspection in addition. In the Argentine special metal bridge inspection staff is not employed, but the Buenos Aires & Pacific Railway stipulates that metal bridges exceeding 7.50 m. (34 1/2 ft.) span must be inspected by a Head Office Engineer; the Rio Grande do Sul Railway of Brazil also favours an Engineer, responsible to the Chief Deputy Engineer.

Inspection of metal bridges is carried out at periods varying widely according to the Administration and country, climatic conditions being obviously of great importance. In Great Britain and Ireland the period ranges from 4 times a year to every 2 years; in India, Burma, Iraq and Africa quarterly to yearly; in New Zealand at least yearly; in Manchukuo and Japan yearly; in U. S. A. generally monthly; in Canada twice yearly; in the Argentine twice yearly to yearly and in Brazil quarterly. This period, of course, refers only to ordinary metal bridges and would be varied in the case of old bridges or bridges known to require special care in their maintenance. Yearly inspection is by far the most common procedure.

Bridge painting.

The procedure adopted in bridge painting shows great similarity in all countries, and it is apparent that mechanical appliances have not yet made great headway for such work, either so far as scaling and cleaning the steelwork is concerned, or in the application of spray painting methods. The reason for this, no doubt, depends on local labour conditions, as obviously in countries such as India and Burma, where labour costs are very low, it will be uneconomical to employ mechanical methods. In Great Britain metal bridges are generally scaled and cleaned by hand, although power tools are being more extensively used, and if patch painting is required this is usually applied by brush, but spray painting is often used for the finishing coat. Cleaning and painting is carried out by hand in the following countries : India, Burma, Ceylon, Africa, New Zealand, Manchukuo, Japan, Argentine and Brazil, although in certain cases experimental work with spray painting has been tried. Spray painting is employed in the U. S. A. and Canada if the extent of the work justifies it.

The general procedure is to scale and clean the steelwork, apply spot coat, then first and final coats, but in many Administrations one of the latter coats is omitted, particularly if spray painting is employed. The intervals at which bridges are repainted generally vary according to the climate and position, ranging mostly from 3 to 8 years in Great Britain and Ireland, 1 to 12 years in Ceylon, India and Burma; 6 years in Iraq and New Zealand, 2 to 8 years in Africa; 6 to 10 years in Manchukuo and Japan; 3 to 7 years in U. S. A. and Canada, with one exception where the period rises to 10 years; and 5 to 8 years in the Argentine and Brazil.

It is the usual practice for all cleaning and painting work on metal bridges to be carried out by Railway Staff, but in India, in some cases, and the South Manchuria Railway in all cases, this work is done by contract. Repairs to metal bridges are generally carried out by Railway Staff but there are a few instances where this work is done by contract.

Large bridges.

Particulars have been given of a considerable number of well-known bridges singular either in type or by reason of their great length or height or both. It is proposed to make special mention of certain of these bridges in order to give details of any special maintenance organisation and methods which are in force.

In Great Britain in the case of the well-known Royal Albert (Saltash) Bridge (fig. 1) (maximum span 445 ft.), a three-monthly examination is made from ladders suspended from the top of the tubes, but there is no special maintenance staff and the same painting procedure is adopted as on smaller bridges. The bridge is repainted at intervals of 5 years. Two large tubular bridges, the Brittania (fig. 2) over the Menai Strait and the Conway (fig. 3) and the Runcorn Bridge (fig. 4) of lattice type, have resident squads of painters, who continually patch paint, etc. A general yearly examination is made by Inspectors and personal inspection by the District Engineer. The Forth Bridge (fig. 5), 8 296 ft. in length, of cantilever type, has maximum spans of 1 710 ft. and a maximum height of 360 ft. A resident Inspector examines different portions of the structure each week and reports direct to the Chief Engineer. A permanent staff of 34 workmen is employed to carry out all repair, staging and painting work. The bridge is painted every three years, painting work being continuous. By way of contrast the Tay Bridge, approximately 2 miles in length, has an augmented staff during the summer months when most of the painting work is done, but in this case the resident Inspector is responsible to the District Engineer. This bridge is repainted every four years. On both bridges a separate staff is responsible for the maintenance of the permanent way.

The High Level Bridge at Newcastle (cast iron arch ribs with tension chains) is not given any special treatment.

In Ireland the Boyne Viaduct (fig. 6) and the Barrow River Bridge are inspected and painted in the same routine as ordinary bridges, the painting being carried out at 4 and 6-yearly intervals respectively

In India, the Silver Jubilee Bridge at Broach (through Baltimore truss girders, 288 ft. centres of piers) has its own Inspector with a small staff to carry out normal maintenance work, not including the permanent way. This bridge is painted in the same manner as an ordinary

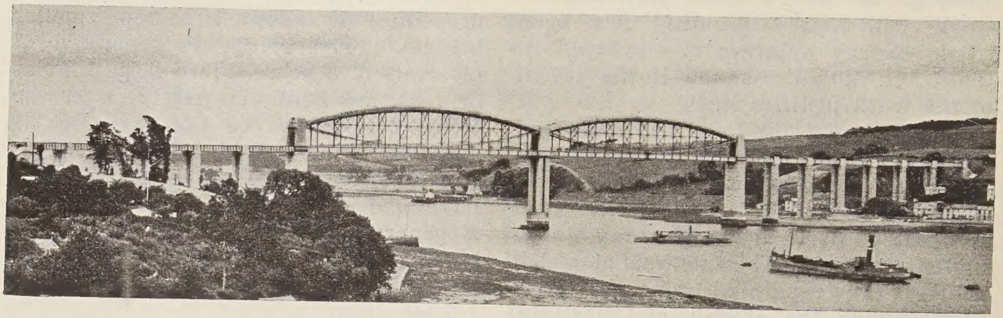


Fig. 1. — Royal Albert Bridge.

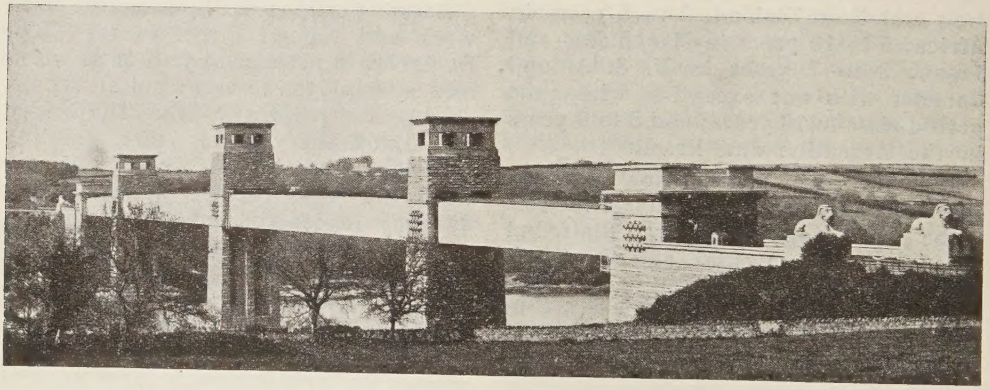


Fig. 2. — Britannia Tubular Bridge, near Bangor.

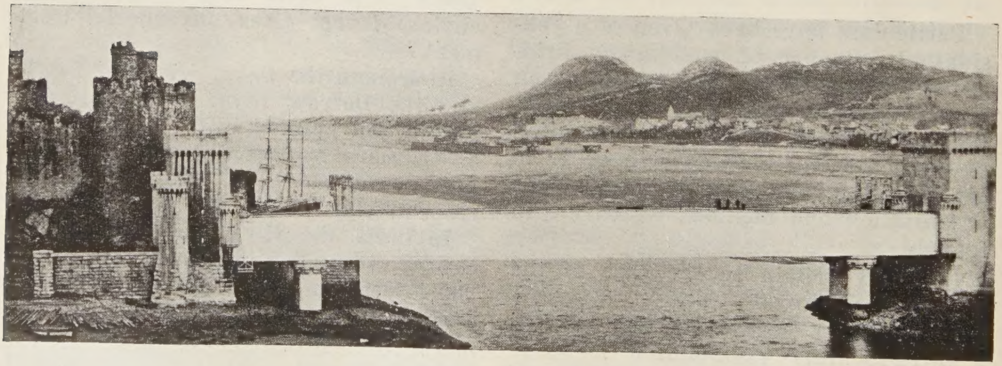


Fig. 3. — Conway Tubular Bridge.

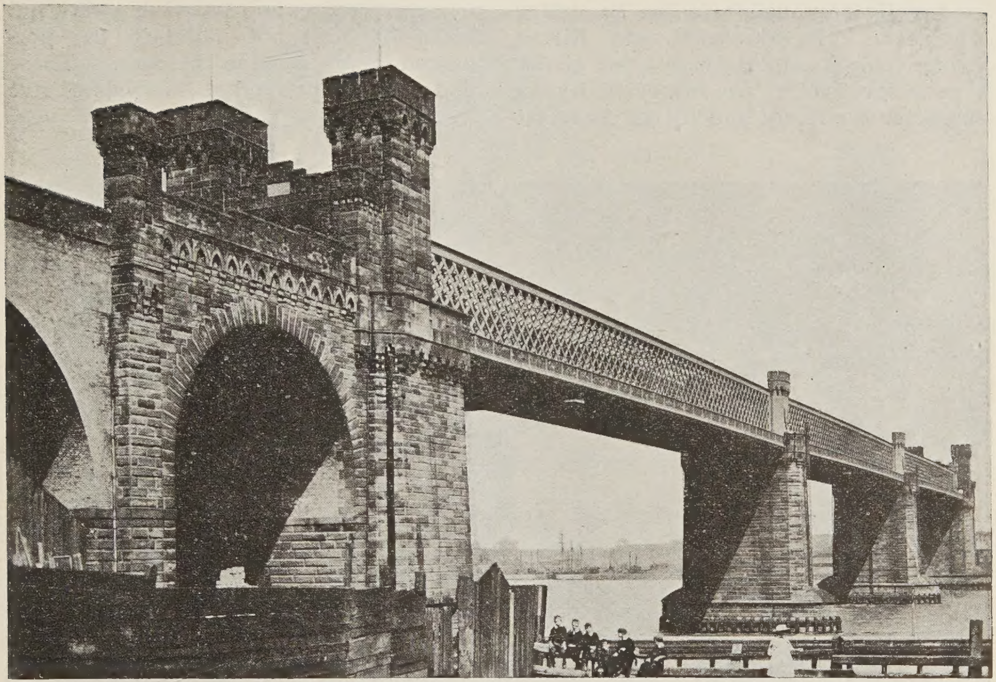


Fig. 4. — Runcorn Bridge, East faces.

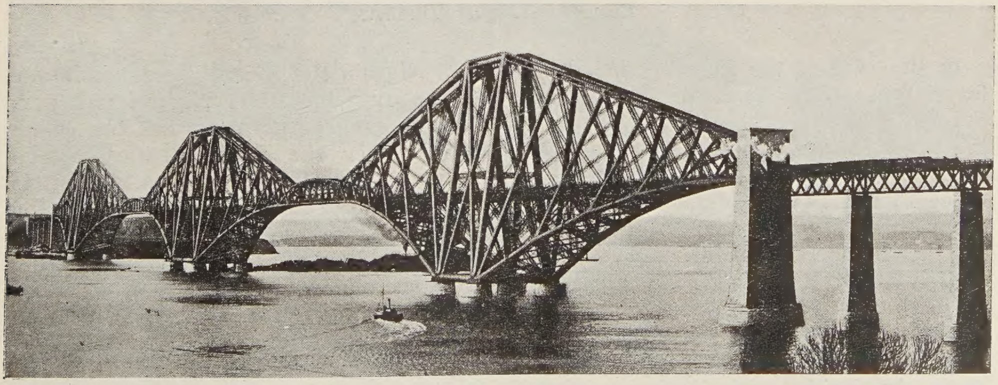


Fig. 5. — The Forth Bridge.

bridge at 5-yearly intervals. The resident Inspector in charge of the bridge is directly responsible to the Executive Engineer. The Godavari and Kistna Bridges (deck and through truss girder type respectively) are inspected by an inspector quarterly and by an Assistant or District Engineer yearly. Permanent staff is attached to each bridge, comprising rivetting and painting gangs, but this staff does not maintain the permanent way on the bridges. These bridges are repainted at intervals of five years.

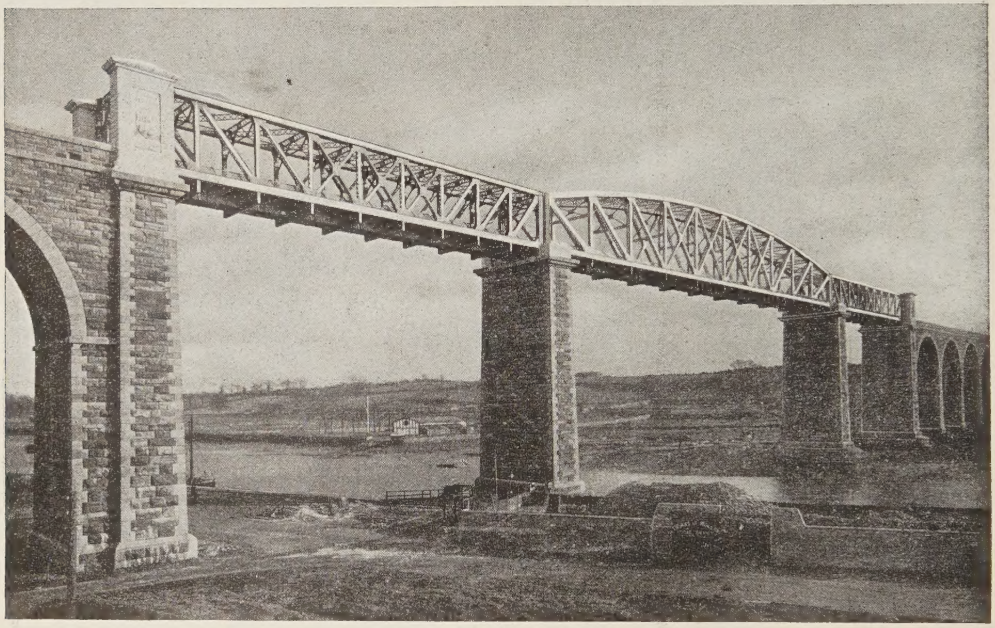


Fig. 6. — Boyne Viaduct.

In the case of the Lansdowne (cantilever type) (fig. 7) and Khushalgarh Bridges (cantilever type) (fig. 8) over the River Indus (span 790 ft. and 459 ft. respectively), a yearly inspection is made by the Inspector of Works, while every three years an inspection is made by the Bridge Inspector. No special staff is maintained on these bridges and no distinction is made with the painting, the routine being the same as in ordinary bridges. Similar remarks apply to the Ara Bridge over the Irawadi and the very high Gokteik Viaduct (1 070 ft. maximum) in Burma.

In Nigeria the recently erected Benue Bridge over the River Niger has a permanent gang of painters, but the Jebba Bridge over the River Benue has no maintenance staff. No distinction is made in the inspection and painting arrangements for these bridges. The Blue Nile Bridge (fig. 9), at Khartoum, includes one rolling lift span and has no special arrangements for inspection or special maintenance staff. This applies to the White Nile Bridge (fig. 10), at Kosti, which has one double swing span, but has a maintenance staff which apparently is responsible for the perma-

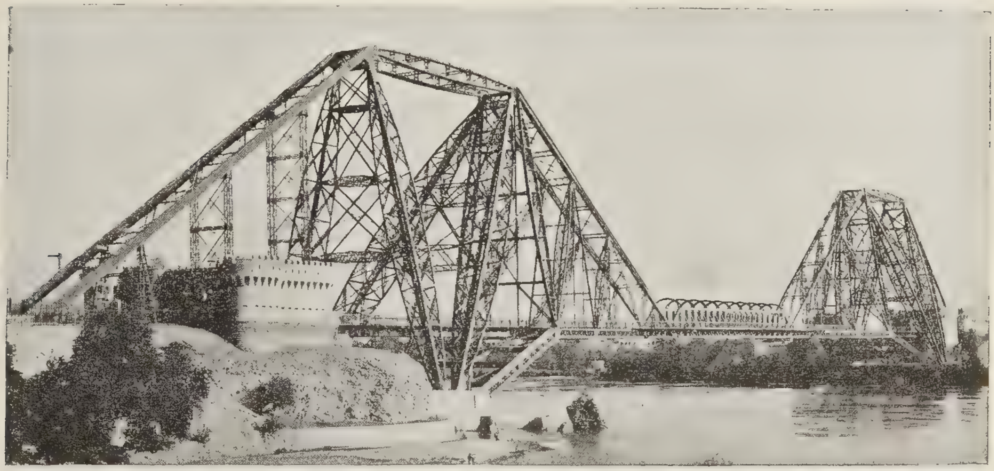


Fig. 7. — Lansdowne Bridge.

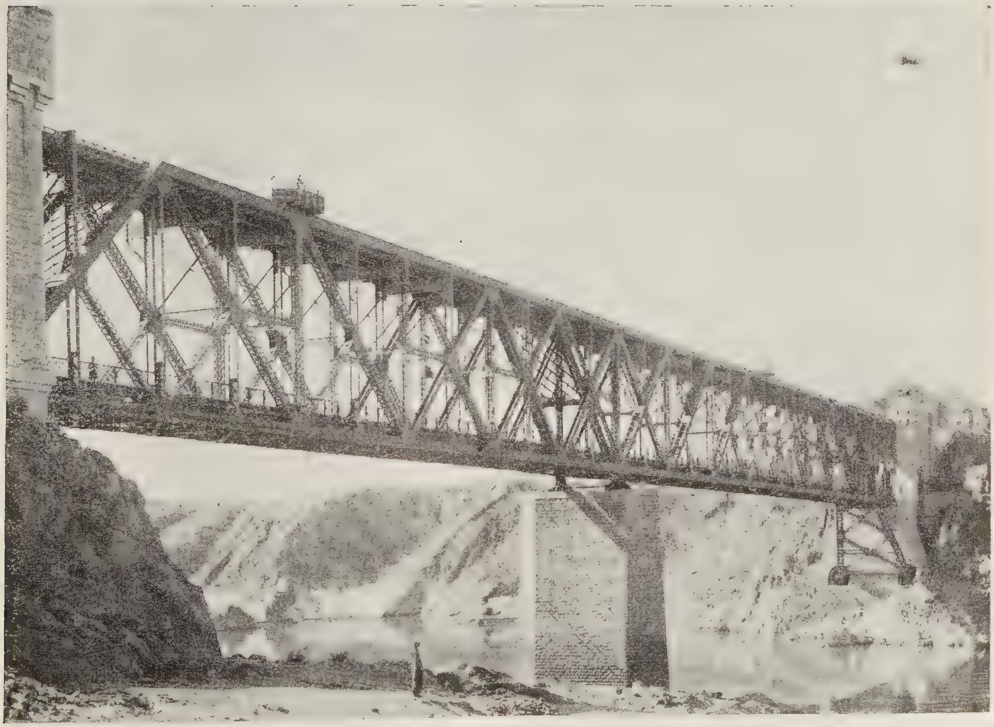


Fig. 8. — Khushalgarh Bridge.

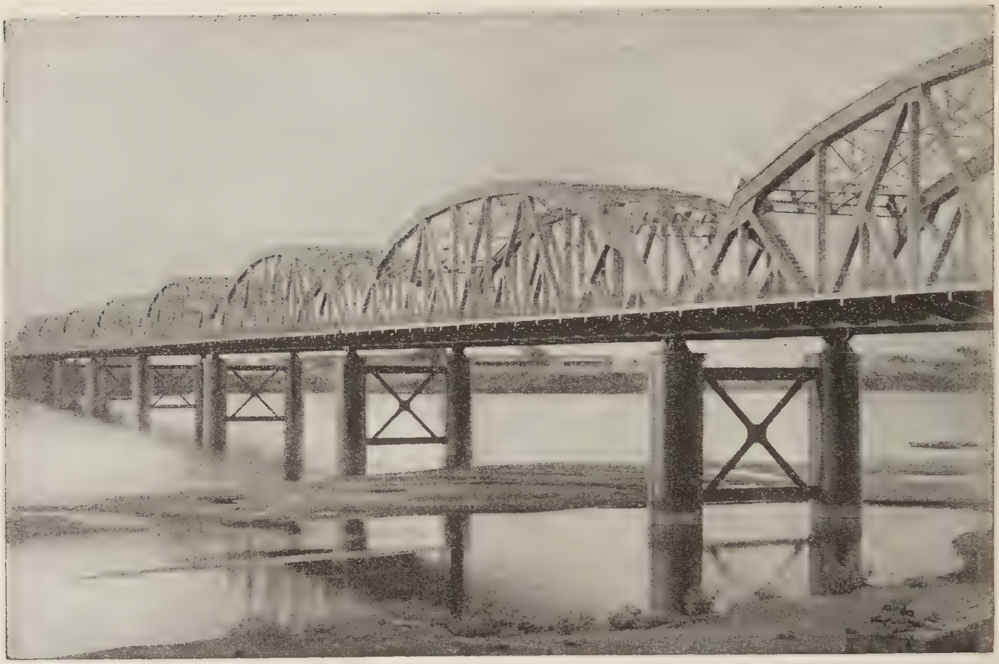


Fig. 9. — Bridge over Blue Nile at Karthoum.

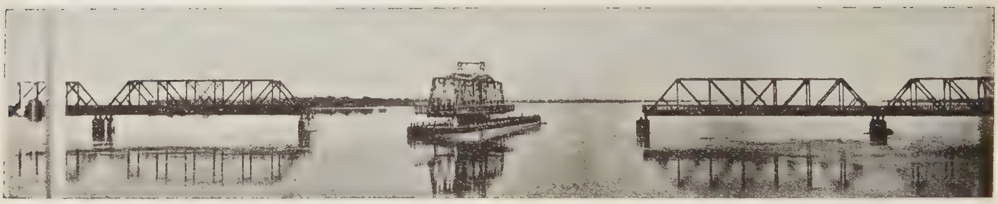


Fig. 10. — Bridge over White Nile at Kosti.

nent way only. The actual painting procedure is similar to ordinary bridges, the repainting taking place at 5 to 6 year intervals.

In Japan the Amarube Bridge (plate girders) noted for its great liability to corrosion and difficulty of maintenance, is inspected by the Supervisor of the Maintenance Section and the Foreman of Engineering Works at 6 monthly intervals, and is repainted in the normal manner every five years. Aganoganwa Bridge, which is the longest (4 080 ft.) in the Japanese system, is inspected by the Supervisor of the Maintenance Section and the Foreman of Engineering Works yearly, and has no special staff, the repainting taking place every 8 years. The Sumidagawa Bridge, which has the longest span (315 ft.) on the Japanese system, is inspected by staff from the District Maintenance Office, yearly. No staff is attached to the bridge, the repainting of which takes place every 5 to 7 years.

In the U. S. A. the Susquehanna River Bridge (through and deck truss girders, 518 ft. maximum span, also plate girder spans) (fig. 11), is inspected by the Division Inspector and Division Master Carpenter once a year, and occasional special inspections by maintenance engineers. No special maintenance staff is attached to the bridge.

A large bridge on the Canadian Pacific Railway, Lethbridge Viaduct in Alberta (fig. 12) has 67 spans (170 ft. maximum) and reaches a height of 314 ft. In addition to the normal twice yearly inspection, special inspections are made by a member of the staff of the Engineer of Bridges as often as is found necessary, no special staff being attached to the bridge, nor is any distinction made in the painting procedure, the repainting taking place every 3 to 5 years. The Quebec Bridge of the Canadian National Railways (fig. 13) is of the cantilever type with a maximum span of 1 800 ft. and a maximum height of 343 ft. 6 in., and is unique in its inspection arrangements, in that, in addition to the normal examination by railway staff, an annual inspection is made by a Consulting Engineer who is paid an annual retaining fee to cover inspection and engineering services on this structure only. It is noteworthy that this Administration has, at various times, employed commercial Inspection Companies to make special inspection of bridges, a procedure which does not appear to have been tried out by any other Administration included in this Report. The Quebec Bridge has its own staff for painting work only and is repainted every 5 to 7 years.

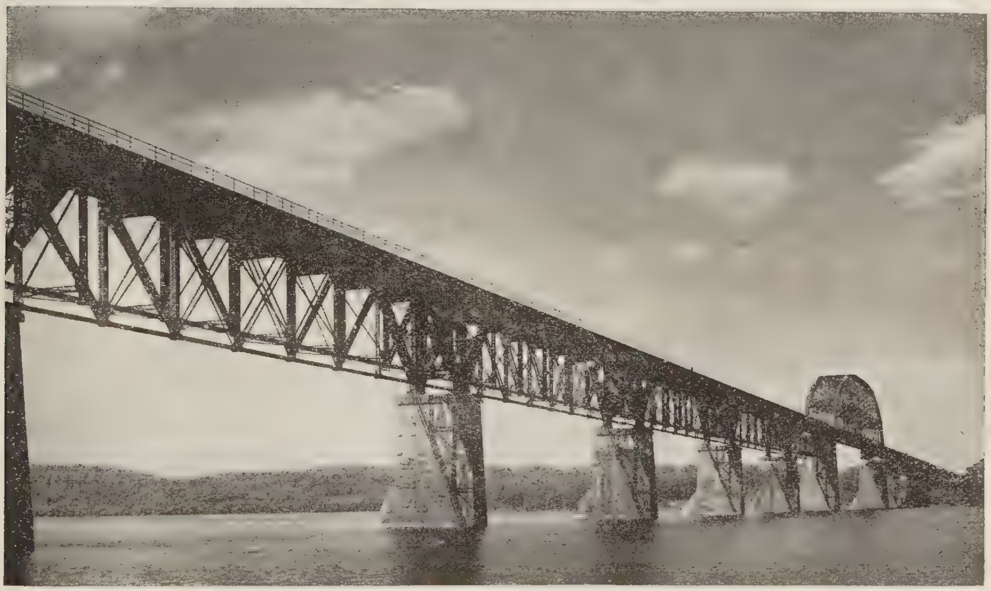


Fig. 11. — Susquehanna River Bridge.

In the Argentine, the Rio Salado

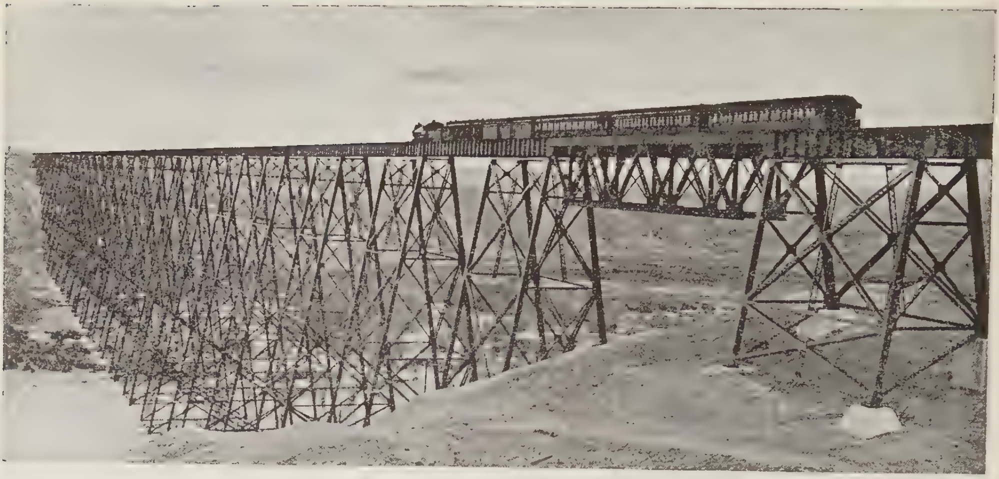


Fig. 12. — Lethbridge Viaduct, Canadian Pacific Ry.

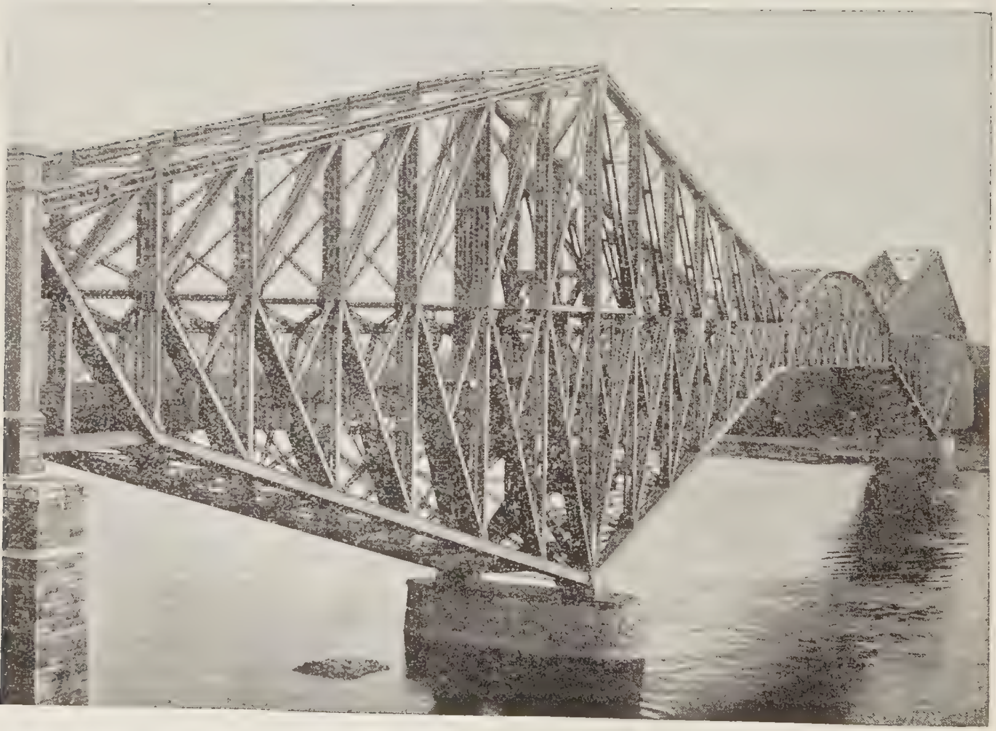


Fig. 13. — Quebec Bridge.

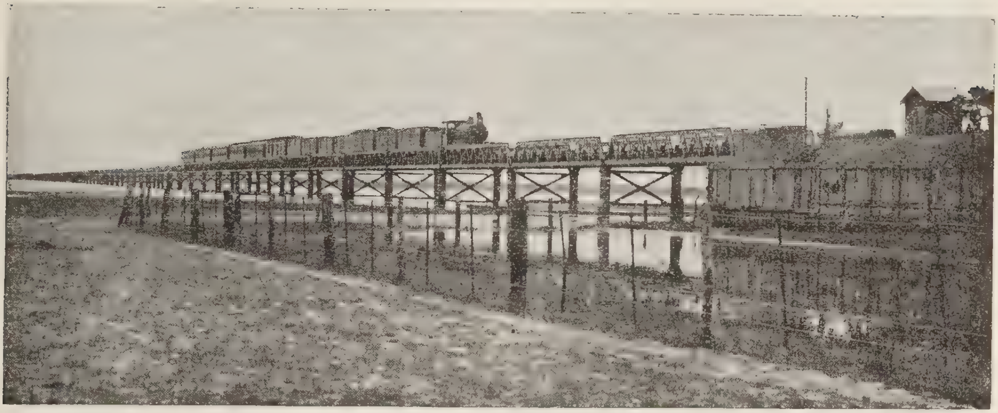


Fig. 14. — Rio Salado Bridge.

Bridge (through Warren type) (fig. 14), at Santa Fe, has no special inspection or painting arrangements. The Chief Engineer of the Division carries out inspections of the bridges over the Rivers Rio Dulce and Rio Negro (both Pratt truss girders). The bridge over the River Santa Maria in Brazil has the normal inspection arrangements, but two men are in charge of the bridge, being more concerned with track maintenance than that of the structure.

Bridge floor types.

In Great Britain and Ireland the most common type of underbridge has a floor consisting either of steel troughing or rail bearers and floor plates, while overbridge floors generally consist of girders and jack arches.

In India, Ceylon, Burma and Iraq practically all underbridges have an open deck, and this must considerably reduce maintenance costs; steel troughing is generally used for overbridges. It is apparent that wherever practicable an open floor is utilised for an underbridge, and troughing, concrete or brick jack arches for overbridge floors. Asphalt or bituminous compositions are generally employed above concrete filling on overbridges for waterproofing purposes.

Strengthening of bridges.

So far as strengthening of defective web or flange plates of girders is concerned, it is evident that electric welding is playing an important part, apparently being the standard practice of most Administrations, although in some countries the method is only now starting to be used. In Africa only the South African Railways and Harbours are beginning to use the process. In the U. S. A. two Administrations carry out electric welding work on bridges by contract, but generally in other countries this work is carried out by Railway Administration staff. All Administrations make use of coated electrodes, with the exception of the Pennsylvania and Reading Railroads, which have used both coated and uncoated electrodes, the latter Administration preferring uncoated electrodes for repairs to old bridges. No Administrations are in possession of any special apparatus such as X-ray plant for controlling the quality of fillet or seam welding, but the London Midland & Scottish Railway utilises an illuminated magnifier (15 diameters) for examining the texture of weld seams for porosity. Extensive use is made of pneumatic rivetting and drilling tools for repair work, the only exceptions to this being the Burma, Bengal and North Western, and Kenya & Uganda Railways.

Smoke troughs.

It is common practice to use smoke troughs or encase the bottom flanges of girders in concrete for protection from engine blast. In some cases cast iron blast plates are utilised, and it is interesting to note that in the case of the Buenos Aires Great Southern Railway the locomotives blast in a horizontal direction centrally between the rails.

It is not usual to specially protect the top flange of girders beyond the normal painting.

Cleaning of steelwork.

Hand work is generally employed for cleaning and derusting steelwork. Most progress with pneumatic and electric scaling tools appears to have been made in Great Britain and the U. S. A., these tools not generally being used in other countries, except on exceptionally large work. Very little use appears to have been made of sand blasting as a means for cleaning steelwork and removing rolling mill scale, two Administrations in India, the New Zealand Government Railways, the Baltimore & Ohio Railroad, the Argentine State Railways, the Rio Grande do Sul Railway (Brazil) and the Canadian Administrations only making general use of the process. It has also been employed in special cases by other Administrations in the Argentine.

Only one Administration employs chemical methods for derusting or removing mill scale from new steel, and in this case a solution of caustic soda is employed. It is the concensus of opinion that it is not economical to derust new steel by sand blast or chemicals with a view to increasing the period between repainting. No experience is available of the derusting procedure adopted for high-tensile steel, which appears to be as yet little used. Metal spraying appears to have made no headway as a means of resisting corrosion, only two Administrations having carried out experiments with this process, one of which states the results have not proved satisfactory. Where bridges are located over salt water it is the general practice, where special protection is required for the underside of the steelwork, to use a preparation which has a tar or bitumastic base.

Painting methods and materials.

Considerable use is made of spray painting in Great Britain, in the U. S. A. and in Canada, but this method of painting does not seem to have made much headway in the other countries under review. The concensus of opinion appears to be that spray painting is more economical than hand work and at least as satisfactory. The spray painting plant generally derives its air supply from a compressor of general utility type suited for supplying other tools and not specially made for spray painting purposes, although in some cases special spray painting air compressors are employed.

Little difficulty appears to have been encountered in housing men employed in remote locations, temporary quarters generally being used. The Administrations of the U. S. A. and Canada provide a high standard of comfort for their travelling gangs by supplying camp cars complete with living quarters, including shower baths.

On new steelwork it is a general practice to use red lead as a priming coat. There are one or two exceptions where red oxide paint, bitumastic or tar paints are used. For subsequent coats red oxide paints are most generally used, although there are cases where tar or graphite compounds are employed.

In Great Britain a total of 4 coats of paint is generally used on new bridges; in Ireland 3 coats; in India 3 coats; in Iraq 2 coats (black bitumastic); in Africa 3 coats, excluding the Sudan which uses one coat of tar paint; other Administrations generally employ 3 coats, except the Buenos Aires & Pacific and Rio Grade do Sul Railways which apply only two coats.

For existing bridges lead base, and in some cases oxide of iron, paints are used in Great Britain for hand work, and lithopone and zinc oxide base paints for spraying, although for this method of painting a special one-coat lead base or iron oxide paint or graphite paints are occasionally used. In India where no spray painting is employed on ordinary bridge work, lead, iron oxide, tar, graphite and bitumastic paints are used. The Iraq Administration makes use of black bitumastic alone. The Administrations of Africa, New Zealand and Japan generally make use of finishing coats of red oxide. The Sudan Railways use a tar paraffin mixture only. In the U. S. A. no distinction is made in the type of paint used for new or existing steelwork or for brush or spray application, and graphite or carbon black paints are common. In Canada, as in the U. S. A. the finishing coat is usually graphite and linseed oil. The most generally used finishing coat in the Argentine is red oxide but tar mixtures are also employed to some extent, while the Rio Grande do Sul Railway of Brazil favours lead base paints.

It is the general practice to apply 2 or 3 coats to existing bridges, but exceptions occur in the case of certain Administrations who instead apply one coat of tar paint. Taking all the Administrations covered by the Report into consideration, the most common practice is to apply one coat of red lead and one coat of iron oxide or graphite compound paint. The second coat is applied immediately the first is thoroughly dry, no appreciable period elapsing between the application of different coats, and the painting follows immediately after the cleaning or derusting process. It is apparent that some of the Administrations, who operate systems in the less densely populated countries, and who need not pay great attention to aesthetic considerations, are in the habit of using tar mixtures.

It is the general practice to entirely repaint a bridge, including the surfaces on which the paint is in fairly good condition. There are only four exceptions to this practice, the Great Northern Railway of Ireland, the Great Indian Peninsula Railway, the Rio Grande do Sul Railway of Brazil and the Japanese Government Railways. The Great Western Railway of Great Britain adopts patch painting if a large area is in good condition.

In certain countries there are statutory objections to the use of lead base paints for spray painting inside work, but this limitation is not yet universal, although desirable, in the interests of the health of the painting staff.

Large bridges.

For the exceptional bridges which have been previously mentioned special scaffolding arrangements to facilitate painting and inspection exist in certain cases only, and it is apparent that such arrangements must conduce to economy and also to the safety of the painting staff. In the case of the Forth Bridge, special permanent travelling platforms, supported from the structure, are provided, and in difficult and inaccessible places a system of scaffolding is arranged which is manipulated from rail level through pulleys fixed on the permanent structure. It is not the usual practice to keep records of temperature, wind pressure and velocity, and expansion and contraction for these large bridges, excepting in the cases of the Forth Bridge and the bridges over the Nile, of the Sudan Railways. On the Forth Bridge these records are read twice daily and plotted in the form of a graph so that any departure from the normal expansion can be immediately detected. The records of the bridges over the Nile are taken twice yearly. The expansion arrangements of these large bridges have given no special difficulty in maintenance, grease, oil or graphite compounds being applied to the rollers at intervals, as required. In some cases this is done when painting is being carried out, but the Forth Bridge has oil injected into the bearings twice per annum which appears to be more frequent than is found necessary by other Administrations.

Electric welding has not generally been used for repair work on these large structures, except in the case of a small repair carried out on the Royal Albert Bridge. Portable compressors are generally used for supplying air to pneumatic tools for use on these large bridges, but in certain instances a permanent pipe is located on the bridge to which a compressor, conveniently located at one end of the structure, can be attached, this pipe then being tapped at the desired point. This arrangement applies to the Forth Bridge, Silver Jubilee Bridge and the Quebec Bridge. With the exception of the Susquehanna River Bridge, the Lethbridge Viaduct, the bridges over the River Santa Maria, Rio Dulce and Rio Negro, and the Quebec Bridge, spray painting has not been adopted on these exceptionally large bridges. In the case of the Forth Bridge experiments with spray painting were tried, but trouble was experienced in manipulating the long lengths of air pipe required and in handling the plant which, coupled with the high consumption of paint owing to wind losses, neutralised the advantages of the process. On the other hand the Canadian Pacific Railway finds that height makes no difference and that if there are many large areas, such as plate girder webs, to be painted, spray painting can be successfully used at a height of 300 ft. This Administration is of opinion that much depends on the operator of the spray, and that trained men can usually overcome by economy the loss of paint due to wastage. The Baltimore & Ohio Railroad is of opinion that there is no limit to the height at which spray painting can be employed.

No special procedure was employed for removing mill scale from these large bridges after erection and the same procedure as is used for other bridges is generally employed for removing rust.

Types of paint on exceptionally large bridges.

Various types of paint are used, the Royal Albert Bridge being painted with lead base paints for both inside and outside work; the Brittania and Conway Tubular Bridges with tar on the top, bottom and inside of the tubes and proprietory paints on the outsides. The practice on the Forth Bridge, where the surface is not defective, is to apply one coat of a high grade oxide of iron paint to the following specification :

Pure oxide of iron paint, ground in genuine linseed oil, guaranteed over 90 % in the dry of oxide of iron (Fe_2O_3) of natural origin.

Where the paint surface is found defective the surface of the steelwork is thoroughly cleaned and prime coated with a mixture made up of two-thirds red lead and one-third white lead (the white is used to hold the red lead in suspension) of British standard quality on top of which are applied two or more coats of oxide of iron paint. On underside surfaces near water level the steelwork receives two and, in some cases, three coats of a heavy bituminous composition.

For the Tay Bridge oxide of iron paint to British Standard Specification is used, except for the under surfaces near water level where heavy bituminous paint is employed.

No distinction from ordinary bridges is made in the case of the painting of the Boyne Viaduct and Barrow River Bridge in Ireland. The Silver Jubilee Bridge in India is painted with a proprietory preparation. Red lead is used for all work on the Godavari and Kistna Bridges, while no distinction from ordinary bridge work is made with the painting of the Lansdowne and Khushalgarh Bridges over the River Indus in India. In Burma the Ara Bridge and Gokteik Viaduct are painted with proprietory preparations. The large bridges in Nigeria are painted with the same type of paint as is used for ordinary bridges. A mixture of tar, paraffin and cement is employed on the Blue Nile Bridge and tar alone is used on the White Nile Bridge in the Sudan. The Japanese Government Railways make no difference in the paint material used for large and small bridges. Black graphite and linseed oil are used in the case of the Lethbridge Viaduct in Canada, while on the Quebec Bridge a first coat of red lead and a second and third coat of a special dark green paint of the following composition is used :

Raw linseed oil	20 % to 21 %.
Boiled linseed oil . . .	16 % to 17 %.
Japan drier	Max. 5 %.
Basic lead sulphite . . .	Min. 33 %.
Zinc oxide	Min. 12 %.
Chromium oxide	Min. 2 %.
Basic lead chromate . .	Min. 1.25 %.
Lamp black	Max. 0.3 %.
French ochre	About 2 %.
Asbestine	Max. 9 %.

On the Susquehanna River Bridge any exposed metal is painted with a priming coat of red lead, 20-lb. to the gallon of paint, and a second coat of carbon black over the entire surface. On erection, in common with other bridges on the Baltimore & Ohio Railroad, this bridge received a first coat of red lead and a second coat made up with 50 % red lead and 50 % carbon black, a third coat being carbon black.

Only in the cases of the Forth and Rio Salado Bridges and bridges over the Rivers Rio Dulce and Rio Negro does it appear that painting work is continually in progress. On the Forth Bridge painting work is so arranged that it takes three years to complete the whole of the inside and outside work, the inside painting work of the tubes being chiefly done during the winter months. The painting work of the remainder of these large bridges can apparently be overtaken without continuous work and is generally undertaken during the more dry months of the year. It is not the general practice to issue instructions to stop painting work when the wind has reached any given velocity, this as a rule being left to the discretion of the Inspector or man in charge.

It is the general practice to provide life buoys, safety ropes, boatmen and boats, or netting for the protection of men engaged on large bridges.

Moveable bridges.

Considerable diversity of practice exists so far as the maintenance of moveable bridges is concerned, in some cases the Civil, the Mechanical or the Electrical Engineer being responsible for the maintenance of the mechanism, and in one case in Ireland the Signal Engineer, and it is apparent that local organisations govern the question. Roller bearings are most commonly employed on swing or lifting bridges, but in certain cases plain bearings are used. These bearings are generally maintained by the Civil or the Mechanical Engineer's Department. In the case of the White Nile Bridge, the maintenance is undertaken by the special bridge staff. Blacklead and tallow, graphite greases and heavy mineral oils are generally used for lubricating these rollers, while in one instance the roller path is lubricated with neat's foot oil and in another sperm oil is used for disc bearings. Where wire ropes are used grease is generally employed as a rope lubricant, usually in the form of a special compound made for the purpose, and no special difficulty is experienced in maintaining the ropes.

Bridges carrying electrified track.

So far as bridges situated on track electrified on the third-rail principle are concerned, painting work is generally carried out during the day. On the Great Western and Southern Railways of Great Britain current can only be switched off for very short periods during the night, but the Pennsylvania and Baltimore & Ohio Railroads of the U. S. A., are able to switch off current for short periods during the day. On the Buenos Aires Great Southern Railway the portion of the third rail spanning the bridge is removed during the whole time the bridge is receiving attention.

So far as bridges on electrified track with overhead conductors are concerned, it is the practice in India for the work to be carried out during the day except on track carrying heavy traffic, and where the current cannot be switched off for short periods when night work for painting the portion near the overhead conductors is adopted. In the case of the Bombay Baroda and Central India Railway the work is done under a « Working Order » and all departments concerned are required to act in accordance with this order, while the Great Indian Peninsula Railway earths the section of line and the work is done under a permit which must be cancelled before instructions are issued to switch on the current. The South African Railways & Harbours find it possible to switch off the current for periods during the day in the case of track carrying light traffic, but the Japanese Government Railways carry out painting work during the day without switching off the current. In the U.S.A., where it is practicable, it is usual to switch off the current for periods during the day in order to reduce painting costs. A representative of the Electrical Department is present, who is responsible for the arrangements for de-energising the section, and in the case of the Reading Company while the power is off overhead conductors are earthed.

2. — SIGNALS.

Organisation.

A special department is generally responsible for the maintenance of signalling. An exceptional case is the Japanese Government Railways where the mechanical part of signalling work is carried out in conjunction with permanent way work under the supervision of the Maintenance of Way Section, and the electrical portion is carried out along with work on the communication equipment under the Communication Section. The Canadian Pacific Railway has no separate signalling organisation, there being a Signal Supervisor on each Chief Superintendent's district. In Great Britain both the mechanical and electrical signalling are maintained by one Department and on two systems this department functions alone, while on three systems it functions as a branch of the Civil Engineer's Department. In Ireland the Signal and Telegraph Department functions alone on the Great Southern Railway, and is attached to the Chief Engineer's Department on the Great Northern Railway, in both cases, however, the mechanical and electrical signalling is maintained by the same department. In Ceylon and the Bengal Nagpur, and Madras and Southern Mahratta Railways of India the mechanical and electrical work is separated, while the Burma Railways have no electric signalling, but in these countries all signalling work is carried out under the Civil Engineer. In Africa the Chief Engineer is generally responsible for signalling work, but on the Nigerian Railway electric signalling is maintained by the Posts and Telegraph Department. The Signal & Electrical Branch of the New Zealand Government Railways functions alone, while on the South Manchuria Railway signalling work is under the jurisdiction of the Electrical Engineer. In the U. S. A. the practice varies, one Administration having a Signal Engineer reporting direct to the Vice-President and General Manager, two Administrations have a Signal Engineer attached to the Civil Engineer's Department and a fourth Administration has a Signal Engineer attached to the Chief Electrical Engineer's Department. In all cases the Signal Engineer maintains both mechanical and electrical equipment. In Canada one Administration has Signal Superintendents attached to the Civil Engineer's Department and the other has a separate staff with the Signalling Supervisors working under the Chief Superintendent (Operating), the same department maintaining the mechanical and electrical apparatus in both cases. Four Administrations in the Argentine have a department which maintains both mechanical and electrical signals and three of these have the department attached to the Civil Engineer's Department, while in the fourth instance it functions alone.

In Great Britain and Ireland the signalling department, in addition to signalling, is responsible for all communications such as telegraphs and telephones, although part of this work is maintained by the Post Office in Northern Ireland. This is not the practice in India, Ceylon and Burma, where only two Administrations utilise the Signalling Department for maintaining certain telegraphs and telephones, and not for all communications. On the South African Railways & Harbours, signal and telegraph work is separated, but on the Sudan Railways the signalling department maintains telegraphs, telephones and tablet instruments, but not the line wires. In New Zealand communications are maintained by the Signal Department, but this is not the case in Manchukuo and Japan, the Communication Section being responsible for the maintenance of telegraphs. The procedure in the U. S. A. varies; some Administrations have a separate department for communications and on others the Signal and Telegraph Department is responsible. In Canada signal and telegraph maintenance work is separated, but in the Argentine this work is combined except on the State Railways.

The organisation of the Signal and Telegraph Department of the British Administrations varies widely, depending largely on whether the department functions alone or as part of another department. The Great Western Railway system is divided into districts, and the London Midland & Scottish Railway is divided into divisions and districts. The London & North Eastern Railway is divided into three autonomous areas and the organisation in each of these areas differs. In one area the District Inspectors are responsible to the Signal and Telegraph Engineer and in another they are responsible to the District Civil Engineers, while in the third the Inspectors are responsible to the District Civil Engineers for mechanical signalling and other Inspectors to the Signal and Telegraph Engineer for electrical signalling. On the Southern Railway the system is divided into sections and districts. The London Passenger Transport

Board presents a special case of a short route mileage (160) carrying very intensive traffic and here the system is divided into Inspectors' Sections. In Ireland one Administration has two Inspectors' Districts, each comprising 5 Linemen's Districts (averaging 50 route miles), the Districts presumably co-inciding with the Civil Engineers' Districts as the department functions under the Chief Civil Engineer, while the other Irish Administration has 5 Signal and Telegraph Divisions (average length 400 route miles) administered from the Head Office. In India and Ceylon systems are generally divided into divisions or districts, with the exception of the Madras & Southern Mahratta Railway where there are two Assistant Signal Engineers, one for broad gauge and one for metre gauge, Signal Inspectors working under the Assistant Signal Engineers. In Burma the Signal Engineer has a Chief Signal Inspector under whom four Signal Inspectors function. The route mileage of these divisions or districts varies widely depending on the number of tracks and stations. As might be expected the minimum mileage is the Bombay District of the Bombay Baroda & Central India Railway (40 route miles), the same Administration also having the maximum district (1 000 route miles) but the most common figure is between 300 and 400 miles. The Nigerian and Sudan Railways have their systems divided into divisions and districts respectively, but the South African Railways & Harbours have an Assistant Engineer (Signals) under the System Engineers, Signal Inspectors working under the Assistant Engineer (Signals). In New Zealand the system is divided into 5 districts in the North Island and 5 districts in the South Island, all under Inspectors, the districts varying from 100 to 300 miles, depending on the equipment. The South Manchuria Railway system has 5 signal districts with an average length of 140 miles. The Japanese Government Railways system is divided into 7 regions (average 1 760 route miles) 44 District Maintenance Offices (average 280 route miles) 193 Maintenance of Way Section Offices (average 62 route miles of mechanical signalling maintenance). The whole system is also divided into 49 Communication Section Offices (average 252 route miles electrical signalling maintenance). The U. S. A. systems are divided into divisions with the route mileage varying from 170 to 540 miles. In Canada the length of district ranges from 1 000 to 3 500 route miles on the Canadian Pacific Railway, although in some cases these districts are not all signalled, while on the Canadian National Railways the average is 2 200 miles. The Buenos Aires Great Southern Railway has 9 Signal Districts (average length 795 route miles) and 10 Telegraph Districts (average length 715 route miles) and the Buenos Aires & Pacific, and Argentine State Railways are each divided into 3 divisions with an average length of 935 and 1 865 route miles respectively.

In Great Britain on each district the London & North Eastern Railway has an average of 166 signal boxes as compared to an average of 100 signal boxes on the Southern Railway; in Ireland the corresponding figure being 14 and 72 for the Great Northern Railway and Great Southern Railway respectively.

The average number of signal boxes on each District in Ceylon is 33, in India about 60, although on the Great Indian Peninsula Railway the number ranges from 94 to 202; in Nigeria 34; in Sudan 45 (mostly ground frames); in New Zealand 15; in Manchukuo 10; in Japan 18; in U. S. A. from 20 to 31 on four Administrations, the number quoted by the Delaware & Hudson Company obviously not being comparable. In the Argentine the number ranges from 45 (including ground frames) to 125.

Of the Administrations covered by the

report, the information available shows the London & North Eastern Railway to have the largest total number of working levers, e.g. 106 899.

Staff.

In Great Britain it is the usual practice to have one Inspector and one Sub-Inspector for each district, although in many cases this number is exceeded; the general average of signal boxes and working levers allocated to an Inspector is 81 and 2 290 respectively. The Great Northern Railway of Ireland has two Inspectors for 10 districts, each of whom is responsible for, on an average, 70 signal boxes and 1 570 working levers, while on the Great Southern Railway of Ireland there is one Inspector and one Sub-Inspector on each division, responsible for an average of 36 signal boxes and 780 working levers. In India, Ceylon and Burma the number of Inspectors per district ranges from one to five who are responsible on an average for 42 signal boxes and 1 101 working levers. In Nigeria a Signal Officer has sufficient staff to admit of one fitter and one labourer for 7 stations, covering an average of 42 levers and 30 Annett locks. No comparable allocation can be made in the case of the South African Railways & Harbours. The Sudan Railways have one Inspector per district responsible on an average for 45 signal boxes covering 487 working levers. Most of the districts of the New Zealand Government Railways have one Inspector for both signal and communication work in each district, who is responsible for, on an average, 15 signal boxes, the number of levers ranging from 275 to 800. The South Manchuria Railway Signal Inspectors are responsible for, on an average, 5 signal boxes and 310 working levers. No comparable figure can be given for the Japanese Government Railways or for the railways of the U. S. A. and Canada. On the Buenos Aires & Pacific Railway one signal and two telegraph Inspectors are attached to each district and are responsible on an average for 95 signal boxes and 992 working levers. On the Central Argentine Railway each district has a signal and also a telegraph Inspector who are responsible for, on an average, 73 signal boxes and 1 045 working levers. Similarly on the Argentine State Railways each Inspector is responsible for, on an average, 10 signal boxes and 500 working levers.

In Great Britain the average number of staff allocated to each Inspector is 59 which represents 39 working levers per man, the grades represented being chiefly Fitters, Installers, Wiremen, Linemen and Labourers. In Ireland (Great Southern Railway) the corresponding average figures are 19 and 41 and (Great Northern Railway) 24 and 65. In India, Ceylon and Burma 73 and 15; Sudan Railways 24 and 20; New Zealand 14 (maintenance only) and 38. No comparable figures can be given for the U. S. A. or the Argentine.

Working hours.

In Great Britain and Ireland, a 48-hour week is standard, and this includes travelling time. At busy locations it is the practice to work shift duties, the shifts averaging 8 hours each. The working hours in India, Ceylon and Burma vary from 8 to 12 per day, including travelling time, and it is common to work shift duties at busy locations, either 8 or 12-hour shifts being adopted. The Nigerian Railway staff has an 8-hour day including travelling time, and it is the usual practice to allow time off in lieu of overtime worked, a similar practice operating on the Sudan Railways. New Zealand has a short normal working week of 44 hours and it is found that shift duties are only required on one or two locations. The South Manchuria Railway has a normal working week of

60 hours and shift duties are worked as is found necessary. In the U. S. A. there is a normal 8-hour day and the Inspectors and Foremen are usually paid on monthly rates and are not allowed overtime for night or Sunday work if required to turn out in an emergency. In Canada the signal maintainers are paid for 240 hours per month which covers all overtime and includes travelling time. In the Argentine an 8-hour day is normal, generally including travelling time.

In Great Britain and Ireland it is the usual practice for an Inspector to be responsible for both mechanical and electrical signalling, but this does not always apply to the Linemen or Maintainers. The practice varies in India, Ceylon and Burma. In South Africa and Manchukuo the same staff are responsible but the Japanese and Nigerian Railways employ different staffs. In the U. S. A., Canada and the Argentine the same staff carry out the work, with the exception of the Buenos Aires Great Southern Railway.

Training schemes.

It is not the general practice to adopt any scheme of training for Signal Linemen or Maintainers, although in Great Britain three Administrations have schemes in force, and the South African Railways & Harbours, South Manchuria Railway and Japanese Government Railways also have training schemes, including theoretical instruction. It is the usual practice to recruit Linemen or Maintainers from the lower grades, basing the promotion on length of service and merit, but the Bombay Baroda and Central India and Sudan Railways promote on a merit basis only. Some Administrations have definite systems in force for training apprentices, particularly the British Administrations and the South African Railways & Harbours.

Working methods.

The following table shows, as far as is practicable, the proportion of levers worked (*a*) mechanically (*b*) electrically and (*c*) by other methods, in the countries under review. The levers covered by the heading « Other Methods » are in some cases stated to be worked either electro-pneumatically or electro-mechanically, in other cases no indication is given.

	Mechanically.	Electrically.	Other methods.
	%	%	%
Great Britain . . .	94.2	4.2	1.6
Ireland	98.8	1.2	...
Ceylon	100.0	...	...
India	89.3	6.7	4.0
Burma	100.0	...	...
Nigeria	100.0	...	...
South Africa . . .	93.2	2.6	4.2
Sudan.	100.0	...	...
New Zealand . . .	86.4	13.2	0.4
Manchukuo	35.0	21.8	43.2
Japan.	89.8	4.5	5.7
U. S. A.	56.2	26.3	17.5
Argentine	85.0	4.3	10.7

In Great Britain the average number of working levers including all types in each district is 3 440; in Ireland the Great Northern Railway 314, Great Southern Railway 1 561; in Ceylon 1 095; in India 2 457; the Nigerian Railway 303; Sudan Railways 487; New Zealand from 275 to 800; South Manchuria Railway 617; Japanese Government Railways about 812; U. S. A. 576; and the Argentine 930.

There is no uniformity in regard to the issue of printed rules for the guidance of Inspectors concerning the work for which they are responsible. One Administration, the London Passenger Transport Board, has a detailed schedule of work for each shift, but this is exceptional and is due possibly to the great density of traffic on this line.

A report regarding the condition of apparatus under the charge of Signal Inspectors is submitted weekly, monthly, quarterly or yearly, but monthly is the most common frequency. It is the normal practice for periodical meetings to be held by the Signal Engineer with the Inspectors, generally at fixed intervals, the only exceptions being the Canadian National Railways who do not hold regular meetings, and a few other Administrations who rely on visits by the Signal Engineers to the Inspectors.

The Signal Inspectors normally keep their Headquarters in touch with their movements by means of telegraph or telephone, in other cases by correspondence, weekly or monthly reports.

There is no uniformity of practice in regard to the Inspector or Lineman riding over their lengths periodically at night for the purpose of ensuring that all signals are giving a good light. Where this practice is adopted, it is in some cases at definite intervals, monthly being the most common and in other cases only when complaints are received.

In a large number of Administrations it is the practice for the Signal Inspectors or Foremen to use trollies, a number of these being power-operated.

In Great Britain and Ireland a Lineman or Maintainer generally has an Assistant or Labourer working along with him. On other Administrations Linemen generally have a Labourer to assist them but in some cases they work alone.

Only in a few cases are printed instructions to Linemen issued.

Maintainers are not generally allowed to disconnect track circuits or signalling circuits for the purpose of taking current readings; if this is permitted, the operation is usually carried out during slack traffic periods or after checking train movements with the signalman. In many cases in which these readings are not permitted to be made by the Maintainer the disconnection and current readings are carried out by an Inspector. Maintainers are usually supplied with a combined volt-ammeter but in some cases with a voltmeter only.

Rules and regulations.

All Administrations have some arrangement in force to ensure that Linemen or Maintainers are acquainted with the Rules and Regulations, particularly those referring to the efficient working of points and signals. Some difficulty is experienced in this connection in India and Burma, as some of the men cannot read English or are illiterate, and it is necessary to have extracts from the Rules printed in vernaculars, or have the Rules read to the men by an Inspector.

In Great Britain it is the practice to exhibit the names and addresses of the Signal Lineman and his Inspector in each signal box except in the case of the London Passenger Transport Board where the details are kept in the Central Traffic Controller's Office. With the Administrations in India and Ceylon this information is generally kept by the Station Masters, while two Administrations in the U. S. A., one in the Argentine and one in Canada require this information to be kept in a signal box. Some Administrations find no need for giving this information.

Disconnection of levers and testing of interlocking.

When a lever has been temporarily disconnected for repairs, in the majority of cases a collar is placed on the lever, in order that the Signalman may be reminded of the fact, but some Administrations consider an entry in the train register book sufficient, while the South Manchuria Railway has no special regulation in force.

Linemen or Maintainers usually work to a programme to ensure regular visits to every location, but on the Canadian National Railways and the Buenos Aires & Pacific Railway the Linemen or Maintainers have no regular programme. Visits to a location for the purpose of overhauling mechanical fittings are most generally made weekly. Considerable variation exists so far as the frequency of cleaning and oiling mechanical interlocking is concerned. At a busy location this is usually required approximately twice as often as at a quiet location.

The ordinary Lineman or Maintainer is not usually allowed to remove and replace the mechanical locking when cleaning or oiling, this work generally being carried out by Locking Fitters, Inspectors or Assistant Inspectors according to the Administration concerned. The Sudan Railways is the only railway which does not keep a record of any interference to the interlocking. In the U. S. A. and Canada, one Administration in India and one in Burma, it is the practice to require periodical tests of the interlocking to be carried out by the Signalman and the results recorded. This also applies on the Argentine State and Buenos Aires & Pacific Railways except that no record is required.

Spare fittings.

With few exceptions the Lineman or Maintainer is permitted to keep a small stock of spare fittings, based generally on one month's user. There are very few cases of Linemen or Maintainers being permitted to store materials in the underpart of a signal box, but where this is allowed the materials so stored are generally checked by an Inspector.

Detector slide clearance.

The standard clearance or tolerance allowed when cutting notches in detector slides or in lock stretcher bars varies from 1/32″ to 1/4″, the most common figure being 1/16″ on either side. About half the Administrations covered by the report supply a standard gauge to Maintainers, to which electrical detection of points must conform, and where this is used the maximum allowable tolerance ranges from 1/32″ to 1/4″ the most common figure being 1/8″; in very few cases is a record kept of the use of this gauge.

Where signal wires cross the track and require protection from the ballast the most general practice is to provide either wood or concrete troughing or enclose these in pipes.

Tools.

There is a general similarity in regard to the tools which are supplied to Linemen by the various Administrations, but a few Administrations supply more comprehensive outfits than others, notably the London Passenger Transport Board whose list comprises 79 different items. A typical list is as follows : spanners, screw drivers, pliers, hammers, chisels, files, drills, reamers, augers, oil can, hacksaw and soldering iron.

The Baltimore & Ohio Railroad of U. S. A., is exceptional in that it requires Signal Maintainers to provide their own tools, and the following extract from that Company's General Instructions may be of interest :

I. — Signalmen, and Signal Maintainers will furnish and keep themselves supplied with the following tools and maintain them in proper condition for efficient work. Assistant Signalmen, Assistant Signal Maintainers and Helpers will furnish and keep themselves supplied with such tools from the list as may be necessary in their work :

1 ratchet brace.
1 set wood bits, 1/4″ to 1″.
1 hand saw.
2 wood chisels, 1/2″ to 1″.
1 hatchet.
1 claw hammer.
1 machinist's hammer.
1 screw driver.
1 steel square.

1 adjustable hacksaw frame, 12″.
1 pair side cutting pliers.
1 pair adjustable side cutting pliers.
1 R.S.A. socket wrench (insulated where required).
1 tool box or bag.

II. — Where an employee is required to maintain line wire, he will furnish and maintain in good condition the following in addition to the above:

1 pair climbers complete.
1 body belt with safety strap.
2 pairs sleeve connectors.

III. — Other tools will be furnished by the Railroad Company.

Portable power-operated machines for such operations as drilling, reamering or grinding are not in general use but are supplied in a few cases for new work and for bonding track circuits. An exception to this occurrs in the U. S. A., where it is the practice to utilise these machines, particularly for work of any magnitude, and in the case of the Delaware & Hudson Railroad a small grinder is issued to each Maintainer.

It is not the usual practice to require Linemen to keep an up-to-date inventory of the apparatus under their charge, only eight Administrations adopting this procedure. It is apparently more usual for the Inspector or Foreman to keep such an inventory.

Types of signals.

In Great Britain upper quadrant mechanically-operated semaphore signals are now standard, except in the case of the Great Western Railway, although large numbers of lower quadrant signals are still in use both types operating through angles varying from 45° to 60°. The South African Railways & Harbours and the Administrations of the U. S. A., and Canada also adopt upper quadrant signals, while the Japanese Government Railways use both three position upper quadrant and two position lower quadrant signals. Other Administrations have retained the lower quadrant type of signal, 45° being the most common angle of operation.

It is the universal practice to fix ladders to all signal posts carrying mechanically-operated semaphore signals, and it is also the general practice to fit decking complete with hand rail to semaphore signal posts for the convenience of Lampmen and Signal Maintainers. Some Administrations provide decking on bracket signals but not on straight posts.

In Great Britain and Ireland the average maximum distance at which mechanically-operated signals are erected from the signal box is 5 280 ft. The corresponding average figure for India, Ceylon and Burma is 3 000 ft.; Nigeria, single wire operation 2 580 ft., double wire operation 3 000 ft.; South African Railways and Harbours 4 000 ft.; Sudan Railways 1 920 ft.; New Zealand 4 500 ft.; Manchukuo 4 920 ft.; Japan 2 625 ft.; U. S. A. from 500 to 2 000 ft.; Canadian Pacific Railway 500 ft.; Canadian National Railways 1 760 ft.; and the Argentine 4 350 ft.

It is the universal practice to carry out periodical tests and overhauls of all electric locks on manually worked frames, these tests usually being supervised by the Inspector, Supervisor or Foreman according to the Administration concerned, and except in the case of the Great Northern Railway of Ireland, the Canadian National Railways, the Buenos Aires & Pacific Railway and the Argentine State Railways a record of the date and results of these tests is kept. It is also, with the exception of the Canadian Pacific Railway, the universal practice to similarly make periodical tests of all apparatus with contact breaking points in electric lock circuits, although special records are not always kept.

Except in a few cases all line and common return wires, either aerial or cable, are periodically tested for insulation to earth and also between wires, and the results recorded.

Electric signal lamps.

About 50 % of the total number of Administrations keep a record of the total burning hours of all electric lamps in colour light signals, and this record is usually kept by the Lineman, Maintainer or Inspector. It is the usual practice to use a lamp in a colour light signal for its full rated life, but there are Administrations who use lamps for only 35 %, 50 %, or 90 % of the rated life, while one Administration, after a lamp has burned 80 % of its rated life on the normally « On » circuit, changes the lamp to the normally « Off » circuit in automatic signal territory. Some Administrations utilise double filament lamps and change the lamp when the first filament has burned out. It is not the usual practice to use lamp relays with double filament lamps so adjusted that the relay « drops away » when the main filament burns out, but the London & North Eastern Railway, Great Northern Railway of Ireland, and the Ceylon Government Railways adopt this practice. The most common procedure is to use a voltage slightly under the rated voltage, the underrun varying from 4 % to 20 % (average 9 %); the actual total of burning hours permitted varies widely, ranging from 800 to 4 000 hours (average 2 300 hours) according to the extent of voltage underrun.

Point rodding.

Tubular or solid point rodding, in some cases galvanised, is most generally used, except in Great Britain and the Argentine. In these countries channel section, mostly galvanised, is adopted, although a few Administrations use tubular or solid rodding. Ungalvanised point rodding is repainted at intervals which range from one to seven years, about three years being the average according to the Administration and locality concerned. A wide range of paints is used for point rodding and there is no similarity even with Administrations operating in the same country. Red and white lead, graphite and red oxide paints are the most common.

Signal arms.

Various methods are adopted for renovating wooden signal arms, some having the old paint scraped or burned off by blowlamp at the site, others being treated by chemicals or sandblast, the paints used being a special oil or enamel signal paint, generally of a proprietory nature. It is apparent that enamelled steel arms are adopted to a great extent, which have the advantage of requiring washing only to keep them in a satisfactory condition.

When signals or signal lights are electrically repeated into the signal box the circuit is always a closed one with the battery or source of supply situated at the signal so that the presence of an earth fault on the line will not give a false indication.

Track circuits.

The procedure with regard to a record of each track circuit filled in periodically by a Maintainer is not uniform, some Administrations keeping such records and others not. Where these records are kept the tests are made at intervals which range usually from weekly to monthly, with a few exceptions up to yearly. In some cases these tests are checked by an Inspector and the cards filed for reference, but in this respect there is again no uniformity of procedure.

In Great Britain the usual minimum allowable train shunt is 0.5 ohm; in Ireland from 0.1 to 0.30 ohm; in Ceylon and Burma 1 ohm; in South Africa 0.5 ohm; in New Zealand 0.05 ohm; in Manchukuo and Japan 0.06 ohm for A. C. circuits and 0.1 for D. C. circuits; Reading Company of U. S. A. 0.1 ohm for A. C. circuits and 0.06 for D. C. circuits; in Canada 0.1 ohm; in the Argentine from 0.5 to 1 ohm. In India it is not possible to state the minimum train shunts owing to varying climatic conditions. If the minimum allowable train shunt cannot be maintained it is usual to shorten the track circuit or improve the drainage by changing the ballast.

The maximum length of track circuit under favourable ballast conditions in Great Britain and Ireland varies from 2 400 ft. to 15 840 ft., the latter length being quoted by the Southern Railway, and with unfavourable ballast conditions the length varies according to circumstances. In Ceylon the conditions for track circuiting are unique in that even under the worst monsoon conditions, provided the tracks are not flooded and the hardwood sleepers are in good condition, there are no unfavourable conditions. In India the length varies from 1 800 to 2 500 ft.; in South Africa under favourable ballast conditions 2 500 ft. and unfavourable ballast conditions 1 200 ft.; similarly in New Zealand 7 000 and 3 000 ft.; Japan 8 200 ft. and 6 560 ft.; Manchukuo 11 500 ft. for A. C. track circuits and 4 920 ft. for D. C. track circuits. In the U. S. A. the distance under favourable ballast conditions ranges from 4 000 to 7 000 ft., and the length would be reduced in sufficient measure to meet abnormal conditions. In Canada the length ranges from 4 500 to 5 000 ft. and 2 000 to 3 000 ft. under favourable and unfavourable ballast conditions, respectively. In the Argentine the length varies from 1 310 to 2 630 ft., the reduction in length due to unfavourable conditions depending on local circumstances.

Fibre is generally used to insulate the track joints at the end of a track circuit, but some Administrations utilise special proprietory types of insulated joints. In some cases the insulated track joints are maintained by the Signal Staff, in others by the Permanent Way Staff and in a few instances both staffs are concerned.

In Great Britain track circuit relays are sent in for overhaul at intervals varying from 2 to 6 years, although 5 years is the most common figure, and a record is kept of these overhauls. In Ireland overhauls are only carried out when they are found to be necessary. In Ceylon and India relays are generally overhauled at periods varying from one to five years and a record is kept, but in Burma they are not sent in for overhaul unless found defective. In South Africa no particular period is specified; in New Zealand 4 to 7 year intervals are adopted, while in Manchukuo and Japan relays are overhauled at intervals of 3 and 4 years, and a record is kept. In the U. S. A. and Canada the general practice is for field tests to determine the necessity for sending in a relay for overhaul while in the Argentine relays are not periodically overhauled.

Electric locks.

There is a considerable diversity of practice in regard to the fixing of electric locks on manual interlocking frames, in some cases this being effected at the front of the frame, in others at the back, and similarly in some cases below floor level, and in others above floor level. A similar variation exists so far as fixing the tappets to the levers is concerned, in some cases the tappets being connected direct to the lever and moving horizontally, in others the tappets being connected to the front or back tails of the counter levers, the locking taking effect on vertically moving tappets. There is no predominance of any one method.

Circuit makers.

Where circuit makers are fitted to semaphore signals for the purpose of repeating into the signal boxes, it is the general practice for a definite angle of movement of the signal from the danger position to open the circuit, this angle generally being laid down for the guidance of Linemen and Maintainers, and the most common figure being 5°.

Cleaning of motor-operated point machines.

In some cases periodical overhaul and cleaning of motor operated point machines is carried out by previous arrangement during no traffic movement but in other cases this is done during traffic movements, some Administrations requiring relative point operating circuits and signal locking circuits to be rendered inoperative during the carrying out of the work, a few Administrations in addition spiking or clamping the points.

Trickle-charged accumulators.

Where trickle charged accumulators are used for track circuits, lever locks, illuminated diagrams, etc., it is the general practice to adjust the charging rate so as to avoid overcharging the accumulators. Only one Administration in Great Britain, the London & North Eastern Railway, instructs the Maintainer to switch off the charging current and run the plant direct from the accumulators in order to prevent overcharging, this being normally done twice weekly for four hour periods. A similar practice is adopted by the Great Southern Railway of Ireland and the Bengal Nagpur Railway of India.

Token instruments.

When transferring tokens from one token instrument to another at the further end of a token section it is the usual practice for the transfer to be recorded by the Lineman and countersigned by the Signalman at each end of the Section, in order to ensure that the correct number of tokens is inserted in the instrument. The record is usually kept in the train or token register book, or, in a few cases, by the Station Master. Perhaps the most complete record is required by the Ceylon Government Railway which requires a total of 8 signatures, there being two at each end of the section in the train register — one by the Station Master and one by the Tablet Transferer — and 4 in the tablet transference book, comprising two by the Tablet Transferer, countersigned by the Station Master at each end of the Section. The South Manchuria Railway and Canadian National Railways do not require a record to be kept, the latter Administration having very few sets in use.

Materials used.

Mild steel is in general use for signal equipment, although some Administrations only employ it for point rodding, pins, studs, etc. Wrought iron is not much used for signalling equipment except in the case of Administrations who do not employ mild steel, such as the Delaware & Hudson Company; three Administrations do not make use of this material, one of them expressing the opinion that it is too expensive. The average user would appear to be in the proportion of about 80 % mild steel to 20 % wrought iron, although the Buenos Aires & Pacific Railway reverses this proportion. It is apparent that the use of mild steel for signalling equipment is increasing.

Only a few Administrations have used electric welding on wrought iron equipment, the results being quite satisfactory, while two Administrations use acetylene welding.

The most common type of post for mechanical signalling is of lattice or tubular steel construction, but a few Administrations employ timber or reinforced concrete posts, one Administration having standardised the latter material. Posts are painted at intervals which range from 1 to 8 years and this interval must, of necessity, depend on the climate and locality, while 5 years is the most common figure. Some timber posts are creosoted and are not painted. Paints having a white lead base are most commonly used, but some use is also made of red oxide, zinc oxide, aluminium, tar or graphite paints.

There is a wide variation in the type of oil used for lubricating outside fittings, point and signal motor mechanism, and point chairs, and it is difficult to find a basis of comparison for the various oils quoted by the Administrations concerned. It would require a detailed comparison of the oil specifications, covering the flash point, gravity and viscosity, to generalise on the best type of oil for each function, and this information is not in all cases available. It is noticeable, however, that a heavy lubricating oil is generally used to lubricate outside fittings, a thinner oil of the « Arctic » type being adopted for lubricating points and signal motor mechanism, while a lower grade of oil is used for point chairs, in some cases even a used engine oil; graphite is also adopted to some extent for the latter purpose. Graphite is not used as a lubricant in Great Britain and Ireland except by the Southern Railway who use graphite mixed with oil on certain types of locking frames. It is used for a similar purpose by some Administrations in India; the South African Railways & Harbours use graphite mixed with paraffin for point chairs and the Buenos Aires Great Southern Railway uses graphite on certain sections as a lubricant for mechanical interlocking and also on point chairs. Graphite is also used by the Argentine State Railways and the Buenos Aires & Pacific Railway.

Lenses, glasses and lamps of colour light signals are generally cleaned at intervals varying from weekly to monthly according to locality and depending on whether installed in rural or industrial areas. In the London area, which carries very intensive traffic, this is done weekly, and in rural areas of the London & North Eastern Railway monthly is considered sufficient. The most common interval is twice a month.

Most Administrations adopt « Searchlight » type signals which are immune from phantom indications due to reflected external light sources, but where this type is not adopted the usual procedure to guard against phantom indications is to blacken the interior fittings or provide hoods or blinds, while one Administration shades outside external lights when these are located near signals.

Maintainers are not usually supplied with covers or shades for placing over the front lenses to guard against exhibiting false indications due to doors or covers being opened, only the South African Railways & Harbours adopting this practice. A few other Administrations point out, however, that doors are only opened at intervals between train movements.

It is the usual practice to test lamps in order to ensure that the filament is accurately located at the focal point, this generally being done by the manufacturer, but in some cases samples from each consignment are tested by the Administration concerned.

Automatic train control.

Only five of the Administrations covered by the Report have automatic train control or cab signalling in service. The Great Western Railway of Great Britain uses an electro-mechanical system, with immovable ramps (about 44 ft. long) fixed in the permanent way for operating the indicating apparatus attached to the locomotive ; in the U. S. A. the Baltimore & Ohio Railroad uses the General Railway Signal Company's Intermittent Inductive Auto-Manual Train Control System, and the Pennsylvania Railroad, Long Island Railroad and Reading Company use the Union Switch and Signal Company's Continuous Automatic Four-Indication Cab Signals, while the Japanese Government Railways contemplate adopting automatic train control, but the system is not yet in service. In all cases the automatic train control track equipment is maintained by the Signal Department and the engine equipment by the Locomotive Department. In view of the small number of Administrations who have adopted automatic train control and the fact that many Administrations are interested in this control, and indeed are carrying out experiments with it, it is proposed to go into the question of the necessary maintenance tests in rather more detail than was considered advisable for ordinary signalling.

The Great Western Railway requires the locomotive equipment to be tested prior to leaving the shed, test ramps being located at the sheds for the purpose, the track equipment being examined monthly by the Linemen and yearly by Inspectors. Enginemen are required to fill in a form in the case of any failure of the apparatus. The locomotive equipment is examined and dealt with in the following manner once every four weeks :

1. Engine battery is changed for a freshly charged battery.

2. Shoe switch is examined and contact pieces cleaned with a soft cloth.

3. The brake valve, siren disc and spindle, and the hinge pin of the brake electro-magnet armature lever are taken out, cleaned, examined and oiled, the floating armature attached to the armature lever is examined for freedom of movement, etc. A superficial examination of the whole equipment is made and finally, the height of the engine shoe is checked by means of a gauge, the allowable tolerance being 1/4″ above or below the correct height.

The Baltimore & Ohio Railroad requires the locomotive equipment to be tested on leaving the shed, this being checked by observation, while the track equipment is tested monthly for location and every four months for electrical characteristics. The instructions covering maintenance of track inductors are as follows :

Definitions.

Train control track inductors are classified, as follows :

(1) « Wound » inductors, or those which contain a coil winding.

(2) « Unwound » inductors, or those which do not contain a coil winding. They are usually made of strap iron.

(3) « Test track » inductors, or those used on ready tracks, consisting of one (1) wound inductor having its coil winding short circuited and two (2) unwound inductors.

(4) « Roadway » inductors, or those located on the line-of-road, approximately seventy feet (70′) in advance of all automatic and semi-automatic block signals.

Instructions.

(1) The first of each month all train control track inductors must be checked for gauge, height and alignment.

(*a*) The center of wound inductor must be maintained eighteen inches (18″) from and parallel with the gauge line of the rail ± 1/4 inch.

(*b*) The near edge of unwound inductor (when made of strap iron) must be maintained fourteen and one-half inches (14-1/2″) from and parallel with the gauge line of the rail ± 1/4 inch.

(*c*) The top of the inductor pole faces must be maintained so as to be two and one half inches (2-1/2″) above the plane of the rails ± 1/8 inch.

(2) Special attention must be given the ties supporting the track inductors — that they are maintained, properly tamped and rail and tie plates spiked securely to the ties, and also that the track inductors are maintained securely bolted to the ties.

(3) Roadway inductors must be tested once every four (4) months in accordance with instructions shown on print file A 69--6-C, revised September 21, 1927, which is made a part of these instructions; also with resonance tester in accordance with manufacturer's instructions, and if the percentage of resonance is less than sixty (60) the inductor must be replaced.

(4) Maintenance of the roadway track inductor circuits must be such as to protect the integrity of the circuit, that is, wires must be kept separated and insulated from each other.

(5) Ballast shall not be unloaded within five feet (5′) of inductor locations.

(6) Tools, rail, tie plates, bolts or metal of any character must not be left on the end of ties where they will project above the top of rail in territory over which locomotives equipped with train control are operated.

(7) Drainage should be provided so that the inductor coil will not be subjected to the effects of moisture. Drainage holes are provided in the bottom plate of the inductor and these should be periodically inspected to see that they are not clogged up. The inductor housing is not watertight, but it is very desirable to prevent wet conditions from existing for a long period.

(8) The external resistance of the roadway inductor control circuit, including resistance of the relay and signal circuit breaker contacts, should not exceed two (2) ohms.

(9) A periodic megger test should be made to check the insulation resistance between conductors in the roadway inductor control circuit. The megger should also be applied between the inductor circuit and ground. In this test the inductor circuit should include the inductor winding and connecting leads. The result of these tests should be tabulated according to dates and locations so that a comparison of results can be made easily at any time.

Should the insulation resistance between the inductor leads, or between the inductor winding and ground, or between the inductor leads and ground become less than three thousand (3 000 ohms), investigations should be made to determine the cause for this low insulation resistance and corrective measures applied.

If the insulation resistance becomes less than one thousand (1 000) ohms., the inductor should be removed from the track, provided the low insulation resistance has been definitely located in the inductor winding.

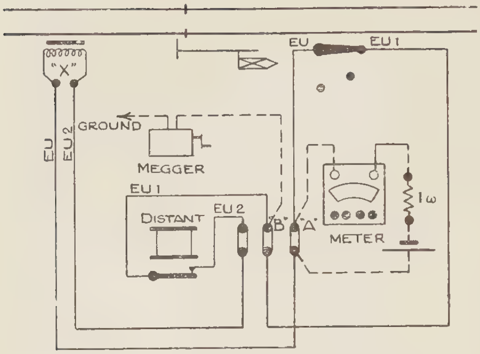
(10) Attention is called to fibre insulations (references 6, 7 and 8, Plate L. 0701, G-R-S-Co's Handbook No. 6) which are used to prevent the pole pieces in conjunction with the housing from setting up eddy current losses around the core. These insulations should be maintained in good mechanical condition, but it is not necessary to maintain any higher insulation resistance than is common with ordinary insulated track joints.

The edges of the fibres under pole pieces must be kept painted with an asphaltum paint, running this paint in the cracks between the edges of the pole pieces and the inductor housing.

(11) General Railway Signal Company's Handbook No. 6 (August, 1926) descriptive of the intermittent inductive auto-manual train control system, is in the hands of all signal maintainers and instructions contained therein should also be followed.

(12) Form X-5 shall be used for rendering reports of inductor tests referred to in paragraph 3 of these instructions.

Figure 15 shows the method adopted when testing Inductor Circuits. The performance of Train Control Track Induc-



To test efficiency of inductor coils and circuits :

Using one cell of Edison storage battery, make voltage test to insure that same is fully charged. Reading should be 1.4 volts,

Connect meter, using milli-ampere scale, in series with battery, one ohm resistance unit and inductor circuit as shown. Reading should be between 200 and 350 milli-amperes. Approximate temperature at time of test should be recorded.

Short circuit inductor coil at point « X ». Reading should be not less than 450 milli-amperes.

Open 90° contact spring on signal mechanism and contact finger on distant relay. Each in turn should cause meters to read Zero.

To test for grounds :

Megger, when connected as shown at « B » with inductor circuit closed, should read 3000 ohms plus; if less than 3000 ohms, investigation should be made to determine cause for low insulation resistance to ground, if megger reads 1000 ohms or less, the inductor should be taken out of service, provided the low insulation resistance has been definitely located in the inductor winding.

Fig. 15. — Method of testing inductor circuits, Baltimore and Ohio Railroad.

tors and Inductor Circuits is reported on a form (Form X. 5) having the following headings :

Signal Number.

East end
West end
Distance from gauge line of nearest rail to center of inductor.
Nearest 1/8″.

East end
West end
Height of top of pole face of inductor above top of plane of main track rails.
Nearest 1/8″.

Voltage of test battery as per Plan A.69-6C.

With test Battery, 1 ohm resistance unit and inductor circuit in series with milliammeter, what is milli-ampere reading?

Does opening 90° contact spring or opening inductor circuit through distant relay produce zero current in preceding test?

What is the approximate outside temperature?

What is the insulation resistance as shown by megger test, as per Plan A69-6C?

I-Choke. — Current through test choke with condenser in circuit.

I-Inductor. — Current through wayside inductor with condenser in circuit.

I-Condenser. — Current through wayside inductor with condenser bridged.

$\% \frac{\text{I-Ind.}}{\text{I-Ch.}}$ = Percentage of resonance of inductor.

The Pennsylvania and Long Island Railroads, who use the Union Switch and Signal Company's system, require the locomotives to be checked when inbound, an Inspector recording this on a standard form, and, in addition, the enginemen are required to make departure tests before leaving the shed territory. Track equipment is not tested at any given periods. The following is extracted from the instructions issued with regard to maintenance of equipment :

Inspection and tests subsequent to arrival at terminal and prior to another dispatchment :

1. Inspect and test the cab signal apparatus and record all defects on Form M. P. 62.

2. Note and record whether or not the pneumatic feature of the magnet valve is cut in.

3. Test dual voltage headlight generator at the generator terminals. Boiler pressure must be within forty pounds of the rated working pressure. Voltage is to be taken for two load conditions :

(*a*) Daylight load; cab signal equipment and those lights which cannot be turned off.

(*b*) Headlight load (250 watts) added to load (*a*), both voltages should be within the limits of 30.5 and 33.5 volts for B-32 and within the limits 350 and 380 for B. 300.

4. Examine all apparatus for loose or damaged parts, including receiver, conduit, conduit fittings, piping and pipe clamps.

5. With automatic cab signal equipment in service, place locomotive on test track section, having rail current adjusted to 1.6 amperes.

(*a*) Operate indication switch on testing apparatus, to give a clear cab signal. After this signal has been held for a few seconds, change indication switch to give approach-restricting cab signal and after warning whistle starts blowing move acknowledging switch to acknowledging position. Warning whistle should sound until acknowledgment has been made. Operate indication switch to give an approach cab signal; warning whistle should sound until acknowledgment has been made; move indication switch to caution-slow-speed cab signal, warning whistle should sound until acknowledgment has been made.

6. When checking cab indications, check signals, both sides of cab.

In addition the instructions give a list of inspection and tests to be carried out at monthly intervals, and others at six-monthly intervals. The performance of the automatic train control system is not reported on a form issued for this exclusive purpose, but a standard form is used which has headings under which any irregular operation may be reported by the engineman. On the Reading Company the track equipment is tested periodically by a Maintainer who checks that the current in track circuits is not above the prescribed limits. A monthly report of automatic train control performance is made to the Bureau of Safety, Interstate Commerce Commission, this apparently being the only instance of a Government Department being thus concerned.

In all cases the track equipment is maintained by Signal Maintainers as part of their ordinary duties, although the Long Island Railroad, while adopting this practice for ordinary maintenance have special Test Men for testing the apparatus.

Centralised traffic control.

Where centralised Traffic Control Installations are in service, these are generally maintained by the Signal Maintainer as part of his ordinary duties, except on the Madras and Southern Mahratta Railway where a special Maintainer is employed and on the Bengal and North Western Railway where the section Assistant Block and Signal Inspectors carry out this work, the Maintainers not being allowed to touch the apparatus. In Burma the maintenance is carried out by the Section Telegraph Inspector, and by the Tablet Chargeman in the Sudan. While the ordinary maintenance of centralised traffic control installations is carried out on the Pennsylvania and Long Island Railroads by the regular Maintainer, the apparatus is tested by a special Test Man at stated periods.

The coding relays in a centralised traffic control system are overhauled annually by the makers in the case of the London Passenger Transport Board; annually by the Baltimore & Ohio Railroad; monthly by the Bengal & North Western Railway, Burma Railways, Sudan Railways and Delaware & Hudson Company. The Pennsylvania and Long Island Railroads test the coding relays in accordance with the routine of a general test schedule. On the Reading Company the frequency of the test inspection depends on the traffic handled. Administrations who use centralised traffic control installations generally depend on instructions issued by the manufacturer for the proper adjustment, calibration and cleaning of all code relay equipment.

Special equipment.

Only one Administration, the Japanese Government Railways, gives any particulars of special apparatus devised for use on signal maintenance work. This system makes use of a handling force meter for determining the force required to handle a mechanical lever (figures 16, 17 and 18) an angle indicator for mea-

Fig. 16.

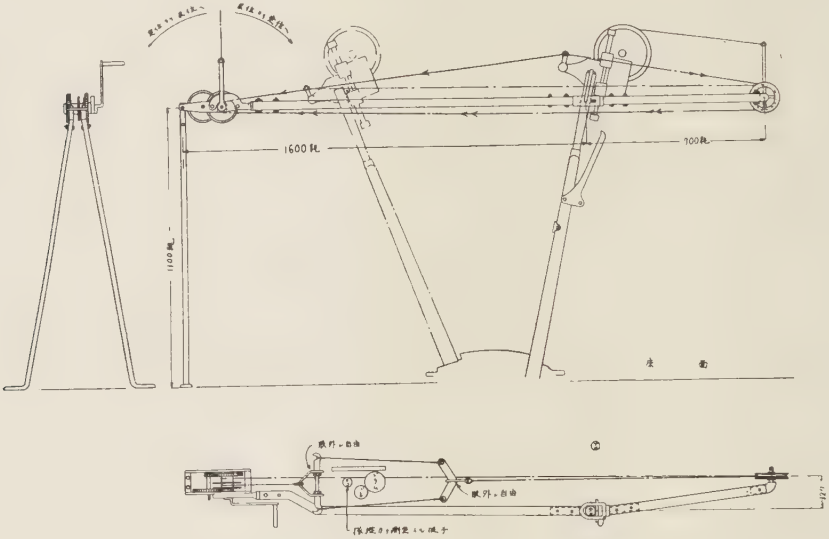


Fig. 17.

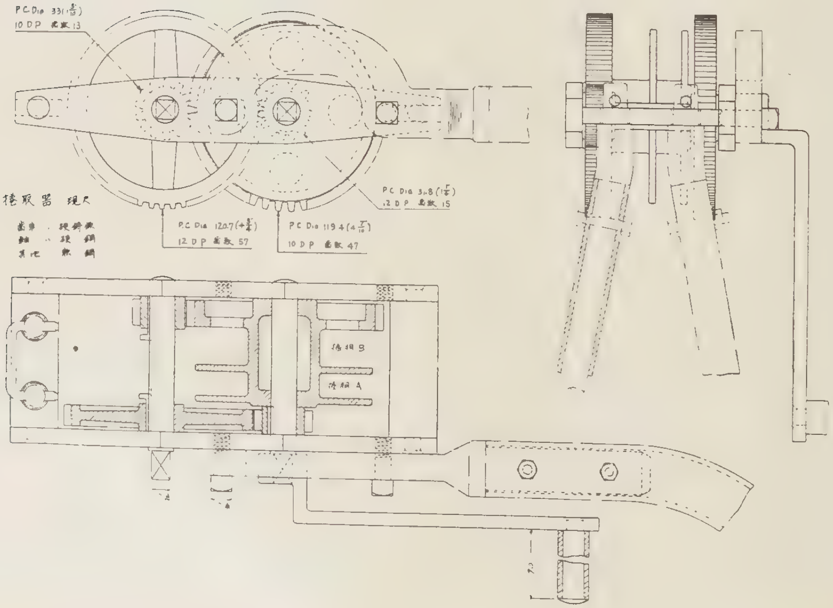


Fig. 18.

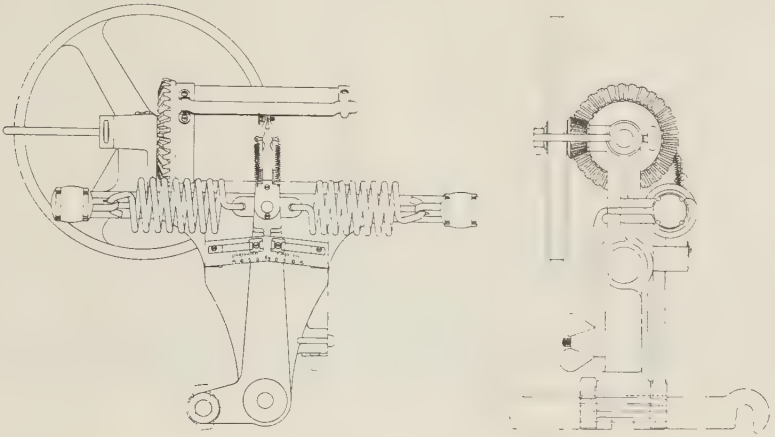


Fig. 16 to 18. — Handling force meter, Japanese Government Railways.

suring the angle at which a signal arm is set, and a spring balance meter for determining the force necessary to throw over points.

3. — METAL SUPPORTS CARRYING CONTACT WIRES ON ELECTRIC RAILWAYS.

Ten of the Administrations who replied to the Questionnaire have electric railways with overhead contact wires, these Administrations being : the London Midland & Scottish Railway; Bombay, Baroda and Central India Railway; Great Indian Peninsula Railway, New Zealand Government Railways; Canadian Pacific Railway, Canadian National Railways;- Pennsylvania Railroad (including Long Island Railroad) ; Baltimore & Annapolis Railroad and the Reading Company of U. S. A.; Japanese Governement Railways and South African Railways and Harbours.

In some cases the route mileage concerned is small, but the Great Indian Peninsula Railway, Pennsylvania Railroad, and South African Railways & Harbours have respectively 181.7, 340, and 560 route miles of track with overhead equipment; the latter figure includes a portion of track still under construction. The following different spacing of supports on straight track occurs — 120, 148, 150, 210, 220, 250, 262, 270, 300 and 330 ft., but the most common spacing is 220 ft.

Organisation.

The Electrical Engineer is generally responsible for the maintenance of contact wire supports; the only exceptions are the Great Indian Peninsula Railway where the Transportation Department is responsible, the New Zealand Government Railways where the Signal & Telegraph Branch is responsible, and the Pennsylvania, and Baltimore & Annapolis Railroads where the Chief Engineer is responsible. The latter are the only cases where the Civil Engineer is responsible for this work, and in both instances he is also responsible for the remainder of the overhead equipment, such as catenary and contact wires. On the Pennsylvania Railroad an Electric Traction Engineer is attached to the Chief Engineer's staff and the track is divided into four regions, each with a Chief Engineer (Maintenance of Way) and a Supervisor (Telegraph & Signals) who is responsible for the wayside portion of Electric Traction, but which is in service on two regions only. The regions are divided into divisions under a Division Engineer and the wayside portion of electric traction is maintained by his Supervisor of Telegraphs and Signals. On the Baltimore & Annapolis Railroad the total length of electrified track with overhead equipment is small and the Linemen report direct to the Chief Engineer.

Where the Electrical Engineer's Department maintains the overhead equipment a Traction Engineer is generally included in the organisation who is in charge of suitable staff for the maintenance of the contact wire supports. The London Midland & Scottish Railway does not have a special maintenance staff for this work, as, when required, men are taken from other duties in the Electrical Engineer's Department. In the case of the Great Indian Peninsula Railway the Traction Engineer has three District Officers who are in charge of the actual maintenance staff. The New Zealand Government Railways, where the Signal & Telegraph Branch is responsible for this work, have a staff, under the Electric Traction Inspectors, distinct from the Signalling and Communications Branch, but the assistance of this branch can be obtained in emergency and for the Canadian Pacific Railway it is indicated that one Foreman and three Linemen maintain the supports for 70 route miles of electrified track. The Canadian National Railways metal supports are maintained by the Lineman in charge of catenary, and the Reading Administration has an Electrical Supervisor in charge of overhead equipment. In Japan the District Electrical Power Office under the Regional Director has an Assistant Electrical Engineer in charge of a power section office with Electricians, Foreman and Linemen to maintain the overhead equipment. In South Africa there is a District Electrical Engineer, under the Chief Electrical Engineer for each of the three systems which have electrified track (Natal, Cape Western and Western Transvaal) under whom the Foreman Electrician with Traction Linemen, Track Bonders and Painters operate; the Traction Linemen maintain all overhead equipment.

Staff.

In all cases the metal supports are maintained by the same staff as is responsible for the remainder of the overhead equipment, and track bonding work is usually also carried out by this staff. The normal man power varies widely as the following figures show :

Bombay Baroda & Central India Railway, 0.625 route miles per man.

Japanese Government Railways, 0.78 route miles per man.

Canadian National Railways (Montreal Electrified Zone), 7.3 route miles per man.

South African Railways & Harbours, 12.0 route miles per man.

Pennsylvania Railroad, 12.5 route miles per man.

Canadian Pacific Railway, 17.5 route miles per man.

No useful comparison can be drawn from these figures owing to the varying conditions. In some cases double track is concerned, in others single, while it is doubtful if precisely comparable staff carrying out similar duties on each Administration was used as a basis of calculation.

Inspection of supports.

There is a wide variation in the practice of the different Administrations as regards the periodical inspection of metal contact wire supports. On the London Midland and Scottish Railway electrified track, examination of the supports is made by a leading electrician and periodical inspection by the Resi-

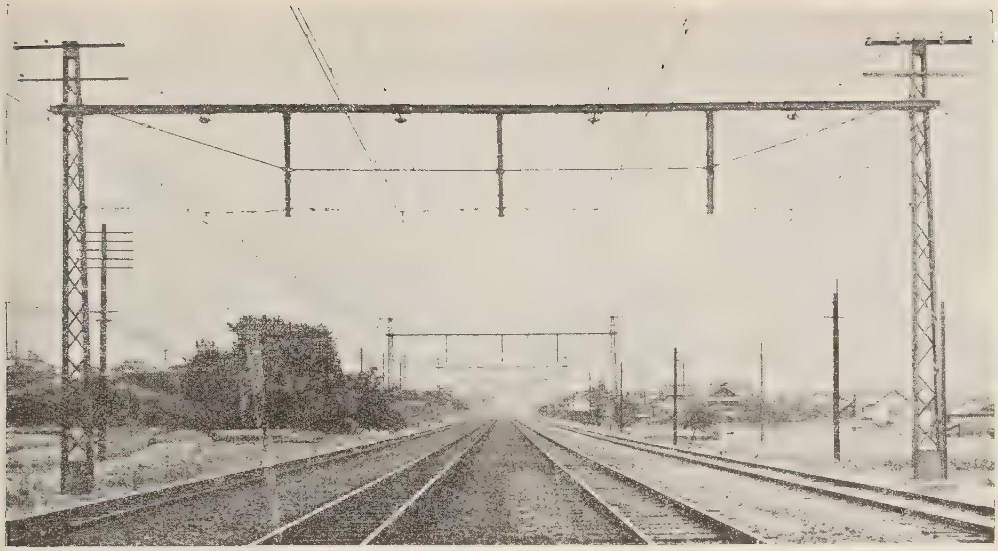


Fig. 19. — Overhead contact wire supports. Japanese Government Railways.

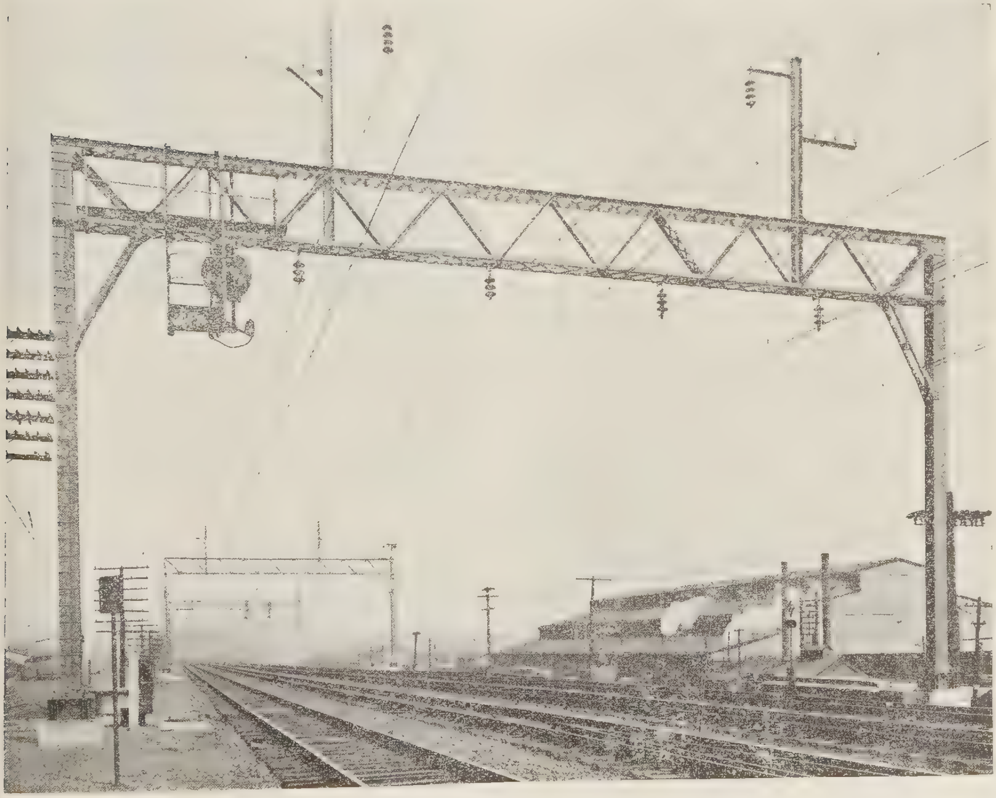


Fig. 20. — Overhead contact wire supports, Reading Company (U. S. A.).

dent Electrical Engineer. The Bombay Baroda and Central India Railway has a half yearly thorough examination of these supports made by the Electrical Foreman (Motive Power) and his staff, but on the Great Indian Peninsula Railway the District Officer only inspects the supports after the scraping, preparatory to painting, has been carried out which is every four or five years. The New Zealand Government Railways have a daily inspection by Traction Linemen. The Canadian Pacific Railway inspection is made every two weeks by Line Foremen or senior Linemen, when the trolley wire is being greased, while on the Canadian National Railways the practice varies according to the section concerned. On one section continual inspection is made when work on the overhead equipment is being carried out, this inspection being carried out by the Electrical Superintendent of Terminals. On the other, a casual inspection is made daily and detailed inspection weekly, by the Electrical Superintendent and Lineman. On the Pennsylvania Railroad inspection is made by the Foreman (Catenary and Transmission) and Supervisor of Track annually or more often if this should be necessary. The linemen of the Baltimore and Annapolis Railroad inspect contact wire supports twice a year. The Reading Company has constant visual inspection carried out by the Patrolman. The Japanese Government Railways have light inspection three times weekly and a thorough inspection twice yearly, this being carried out by the Electrician, Foreman and Lineman. On the South African Railways & Harbours all electrified sections are patrolled by Traction Linemen daily for the purpose of inspecting overhead equipment and supports.

Types of supports.

In most cases supports consist of rolled steel sections or steel lattice work structures (figs. 19 and 20). The New Zealand Government Railways, however, use mostly iron bark hardwood poles, the Canadian Pacific cedar poles and the South African Railways & Harbours, with the exception of cantilever arms and bridge booms which are of standard channel section, utilise a very economical arrangement by electrically welding together by means of batten plates, two 60 or 80-lb. per yard scrap rails. The Baltimore & Annapolis Railroad use wood poles with metal brackets and cross spans (fig. 21).

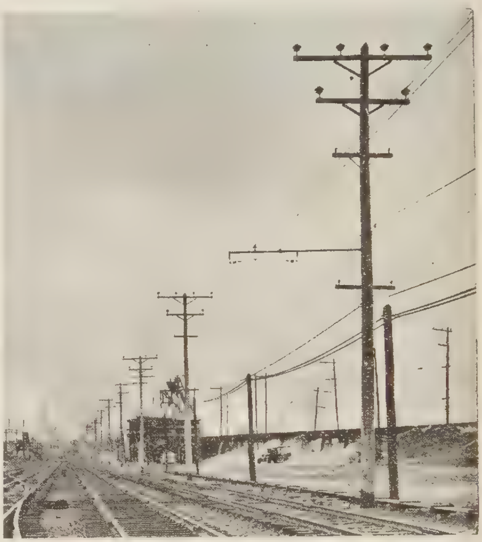


Fig. 21. — Bracket construction on tangents, Baltimore and Annapolis Railroad.

Foundations.

In practically all cases concrete foundations are used, but the Canadian Pacific Railway merely set the poles in the ground, while again the South African Railways & Harbours use an interesting and unorthodox type of foundation consisting of two pre-cast reinforced concrete sleepers, one upper and one lower, so positioned that they counteract the force set up by the loading of the overhead equipment. These sleepers are approximately 5′ × 15″ × 8″ and are reinforced with rods (fig. 22). This type of foundation has the great advantage that it can be very easily re-set should any tilt develop in the support, and obviates any necessity for specially devising means of counteracting tilting, which with the ordinary concrete foundation generally requires either new foundations or increased foundation area, jacking up to correct position and packing, stay wires, sheet piling, or ties under the track connected to the opposite structure.

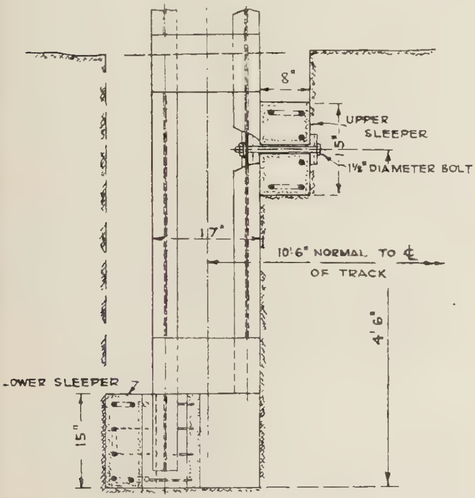


Fig. 22. — Contact wire support foundation, South African Railways and Harbours.

Only the Canadian National Railways have found that anchor supports require more maintenance work than ordinary supports.

Painting.

Supports are painted at intervals, varying widely according to the Administration concerned. In some cases, owing to the recent erection of the overhead equipment, no repainting has yet been necessary. On the London Midland & Scottish Railway a first repainting took place four years after erection, this probably being increased to 5-year intervals for subsequent repainting, while on another section which has been electrified for a longer period, three-year intervals have been the practice. In India 4 to 5 years is the average figure; in New Zealand where, in some cases, galvanised metal supports are used repainting is done at 5 year intervals. The cedar poles on the Canadian Pacific Railway have not been painted since erection 19 years ago, while on the Canadian National Railways painting is only done as opportunity permits, some of the supports, about 28 years old, being still in good condition, while others are galvanised and are not repainted. The Pennsylvania Railroad repaints approximately every 2 years, and the Reading Company anticipate they will repaint 5 to 6 years after erection; the Japanese Government Railways adopt a 3 to 4-year interval and the South African Railways & Harbours every 5 years.

After cleaning and chipping, red lead is generally used as a priming coat and, in the case of the London Midland & Scottish Railway, this is followed with two coats of grey paint with a white lead base, while the Bombay Baroda and Central India Railway follows this with one or two coats of composite protecting paint and in some cases aluminium paint. The Great Indian Peninsula Railway uses aluminium paint as a finishing coat; the New Zealand Government Railways formerly used a lead base paint as a finishing coat, but are experimenting with aluminium paint. On the ungalvanised supports of the Canadian National Railways black graphite (Mexican Black Graphite in Linseed Oil) is employed. The Pennsylvania Railroad uses aluminium paint for the finishing coat made up with 2 lb. of « Polished » aluminium bronze powder in one gallon of mixing varnish, but the Reading Company uses lead base paints for both coats. The Japanese Government Railways employ, in addition to red lead, a range of paints based probably on the circumstances at different localities, including a paint which is composed of lead chromate in specially treated drying oil, and another composed of metallic zinc powder in waterproof varnish. The South African Railways & Harbours use a proprietory paint which has a graphite base.

Painting work is carried out by railway staff with the exception of the Japanese Government Railways who contract this work, and the Great Indian Peninsula Railway which normally carries out the painting departmentally, but is now trying contract work.

Safety precautions.

It is usual to cut off the current when carrying out painting work, but on the Bombay, Baroda & Central India Railway the vertical supports up to a point 3 ft. below the cross span are painted with the current on, and the remaining portion of the vertical supports and the horizontal members after the current is cut off. A similar practice applies in the case of the South African Railways & Harbours. The Canadian National Railways and the Japanese Government Railways do not normally cut off the current for painting purposes. In the former case great care is exercised to ensure that workmen keep well away from live wires while the current is on, and in the latter painting work near live wires is carried out with rubber shields on the wires.

No Administration employs pneumatic or electrically-operated scaling tools for cleaning the steelwork of supports and in all cases paint is applied by brush. The South African Railways & Harbours spray paint the supports on fabrication, but after erection on the track paint work is carried out by brush.

Three Administrations use galvanised metal for supports and one for brackets and cross spans, but one of these finds it necessary to paint the steel in spite of this. No Administration has used metal spraying as a means of protecting metal supports against corrosion. In view of the fact that the metal supports on the South African Railways & Harbours are electrically welded, repairs are executed in a like manner, and electric welding has also been used for repair purposes by the Reading Company and Pennsylvania Railroad, the latter Administration also making use of gas welding according to the nature of the repair work involved.

SUMMARY.

1. The maintenance of metal bridges is generally carried out by staff separate from the staff responsible for the maintenance of the permanent way.

2. Inspection of metal bridges is generally carried out by special staff, the most common frequency of inspection being yearly.

3. Systems are usually divided into regions, divisions, or districts for maintenance purposes; this applies to metal bridges and signals, and, in some cases, metal contact wire supports.

4. In most cases repairs to, and repainting of, metal bridges are carried out by railway staff.

5. The frequency at which a bridge requires to be repainted varies according to the locality and climate of the country concerned.

6. It is usually economical to employ pneumatic or electrically-operated tools when extensive repairs to metal bridges are necessary.

7. Electric welding can economically be employed for bridge repair and strengthening work.

8. Hand work is generally employed for

cleaning and derusting steelwork; most progress with pneumatic and electric scaling tools has been made in Great Britain and U. S. A.

9. Spray painting methods can often be economically employed when repainting bridges.

10. The maintenance of signals is undertaken by a special organisation which is generally attached to the Civil Engineer's Department.

11. The organisation of the various Signal Departments differs widely, and usually depends on local conditions.

12. Linemen or Maintainers are generally permitted to keep a small stock of spare fittings, often based on one month's user.

13. The most common clearance or tolerance allowed when cutting notches in detector slides or in lock stretcher bars is 1/16 inch on either side.

14. Linemen are generally supplied with the necessary tools.

15. Portable power operated machines, such as drills and grinding machines, are not generally used for signal maintenance work.

16. It is the universal practice to carry out periodical tests and overhauls to all electric locks on manually worked frames.

17. It is the usual practice to use a voltage slightly under the rated voltage for lamps in colour-light signals.

18. The maximum length of track circuit and minimum allowable train shunt vary according to the local conditions and climate.

19. It is the general practice to adjust the charging rate of trickle-charged accumulators so as to avoid over-charging.

20. Mild steel is generally used for signalling equipment, and the use of wrought iron is decreasing.

21. Automatic train control track equipment is maintained and tested by the Signal Department, and engine equipment by the Locomotive Department.

22. Locomotives fitted with automatic train control equipment generally have this tested on entering or leaving the shed.

23. With few exceptions, the Electrical Engineer is responsible for the maintenance of metal supports carrying contact wires on electric railways.

24. Metal supports are usually maintained by the staff responsible for the remainder of the overhead equipment, and track bonding work is generally also carried out by this staff.

25. Metal supports are inspected periodically but the frequency of this inspection varies widely.

26. Metal supports are painted at intervals which vary according to the location and climate, but every 5 years is the most common frequency.

27. Hand work is generally used for cleaning and painting metal supports, this work usually being carried out by railway staff.

[656. 21]

A comparative study of road motor transport regulations,

(*4th article* *),

by VLADIMIR IBL,

Engineer, Manager of Road Services, Czechoslovak State.

The Enumeration of the legislative and administrative enactments quoted in our previous articles has to be completed by the following :

Enumeration of the legislative and administrative enactments regulating road motor transport in the different European countries.

(Third Supplement).

Austria.

Addition to point 1.

Law No. 294 of the 3rd October 1931 instituting concessions for public passenger services with fixed routes and timetables is completed, as regards the control of such services, by decree No. 234 of the 13th April 1934.

A new order on the application of this law, No. 43 of the 19th May 1934, makes certain additions, such as regulations on carrying passengers in lorries employed in services with fixed routes and timetables, on the control of such services, on driving licenses for the drivers of public service vehicles, and on the withdrawal of such licenses, etc.

Addition to point 4.

Decree No. 253 of the 9th June 1933 has been extended several times, the last time until the 31st March 1936.

Addition to point 5.

Ordinance No. 138 of the 12th May 1930 putting into force law No. 437 of the 20th December 1929 on the use of motor vehicles, has also been completed by *Order No. 311 of the 18th October 1930.*

The road regulations, originally governed by *law No. 438/1929*, modified by subsequent laws (No. 79/1930, No. 386/1931 and No. 335/1934), was the subject of a *new basic law published on the 15th May 1935*, put into force *by an order dated the 13th June 1935.*

Addition to point 7.

As regards *taxation*, the provisions of law No. 294 of the 3rd October 1931 on the petrol tax, and *law No. 45 of the 28th January 1931* introducing this tax,

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(*) See *Bulletin of the Railway Congress :* (1) May 1935, pp. 544 to 556 — (2) February 1936, pp. 130 to 149 — (3) June 1936, pp. 582 to 597.

have been altered by : *Order No. 404 of the 4th September 1933; law No. 62 of the 8th June 1934*, this latter also modifying the other taxes (traffic taxes) introduced by law No. 294/1931; *law No. 273 of the 31st August 1934* followed by *order No. 280 of the 10th October 1934* putting it into force; *law No. 152 of the 30th April 1935* abolishing the traffic taxes imposed by laws Nos. 45/1931 and 294/1931.

Bulgaria.

Addition to point 1 (see 3rd article, p. 582).

The law of the 23rd April 1935, published on the 21st May 1935, refers to the following three regulations :

« *Regulations on the circulation of motor vehicles on the roads and in towns* ».
« *Regulations on the operation of road motor services* » as regards their commercial management, and
« *Regulations on special requirements regarding the operation of motor services* » (applicable to the staff and the vehicles used on such services).

These regulations are now in preparation, and as soon as they will have been published it will be possible to get a more exact idea of the whole legislation governing motor transport and the circulation of motor vehicles in Bulgaria.

It should also be noted that in Bulgaria the routes of motor services for which contractors may obtain concessions were laid down beforehand. The list of such routes, approved by the Minister of Railways, Posts and Telegraphs, was published in July 1935.

2. *The safety of road motor traffic* will be dealt with chiefly by the first of the three Regulations mentioned above. However, the law published on the 21st May 1935 contains in chapter IV, regulations covering the acceptance of motor vehicles, their periodical inspection, and the duties of the drivers. The road law (see further on) in chapter VII debars from using the public roads motor vehicles which by reason of their weight, dimensions, or speed, are likely to damage the roads or make them unsafe, and forbids the use of any tyres other than pneumatics or semi-pneumatics.

3. As regards the *taxes* on motor vehicles and motor transport, it should first of all be noted that apart from the petrol tax, paid on importation, clause 6 of the « Road Law » (see later on) dealing with the fund for rebuilding, equipping, and repairing the public roads, imposes fixed annual taxes varying with the class of vehicle, and an additional tax on all tickets sold in the buses.

4. The classification of the roads, the technical specifications for their construction, the creation and maintenance of a road fund considered under the previous heading, are all dealt with in the *decree on road traffic*, published on the 28th December 1934.

France.

Addition to point 1.

The decree of the 9th July 1935 setting up a Higher Transport Co-ordination Committee was modified by the *decree of the 5th October 1935*.

Italy.

Addition to point 7.

Decree No. 2097 of the 2nd December 1935 regulating goods rates, introduced taxes on road goods transport, not only in the case of public services but also on transport in private lorries.

Czechoslovakia.

(Addition to point 1 of Supplement given in the second article).

Law No. 77 of the 12th April 1935 reserves for the Post Office certain control rights over professional goods transport in the case of small parcels which by nature may be considered as post parcels. *Ordinance No. 229 of the 13th December 1935* gave the necessary definitions in this connection.

* * *

AMENDMENT TO CHAPTER TWO.

As BULGARIA *has recently joined the countries in which road motor transport is regulated by law, we think it will be interesting briefly to indicate how Bulgarian legislation compares, from the point of view of Chapter Two of the present investigation, with that of the other countries, in other words to show how the regulations affect the different classes of motor transport and the definitions given thereof.*

The special Bulgarian regulations (law published on the 21st May 1935) only cover *public passenger and goods transport,* and only affect private transport as regards registration of vehicles ; *public* transport is defined as that worked for payment, and *private* transport that worked in vehicles owned by the person for whom the transport is carried out.

The regulations also cover both *regular public services* and *occasional transport* worked professionally.

Clause 3 of the *law of the 21st May 1935* defines *regular* services as those linking up two given places and working to a fixed timetable at least once a week. On the other hand, the law treats as *occasional,* transport worked between places where regular services have not yet been organised, excursion services, or such services as cannot completely meet the traffic requirements.

The Bulgarian legislation distinguishes in the same clause between *permanent services* and *seasonal services,* the latter including any not lasting over six months.

The special Bulgarian law excludes *Urban passenger transport* from the regulations, as the municipalities alone are considered as authorised to organise town passenger transport in common.

This law makes a clear distinction between *passenger transport « in common »* and that worked in hired vehicles *(taxis),* the latter being defined as those with not more than 7 seats including the driver's. In comparison with transport in common, the regulations on taxis are less strict, but in the case of inter-urban traffic the operators must obtain a special licence.

* * *

CHAPTER THREE.

First attempts to regulate private goods road transport.

In the *foreword* to the present study (first article, p. 143) we foresaw the necessity of examining if and how, in the countries with which we are dealing, « in the public interest and in order to meet the needs of a reasonable transport policy, the different regulations in force are intended . . . . . ultimately to bring private goods road transport within the scope of such a policy ».

At the time we wrote these words, *Austria,* alone of the countries with which we were dealing, had taken any steps in this matter. *Order No. 253 of the 9th June 1933* (see first article, p. 545) regulating motor goods transport and in particular laying down minimum rates for *public* transport of this sort, forbids *private* transport parallel to the railways for more than 100 km. (62 miles). This order, the application of which was several times extended for a further period, remained in force until the 31st March 1936. Negociations to extend it with certain modifications are now in hand.

Since then, however, three other countries have attempted to regulate private goods road transport.

As we already pointed out in our second article (p. 136), *Czechoslovakia* was the first of these countries, and profiting by a revision of the old legislation, introduced by a clause *in law No. 77 of the 12th April 1935* a tax intended to make the private owners of motor lorries (factories, traders, etc.) used on their own behalf come to some agreement with the railway about the use of motor vehicles. The supertax intended to bring this about will be due on the 1st January 1937.

On the other hand we have already stated in our third article (p. 582) that in *France* the regulations formerly only applicable to professional carriers have also been extended to private motor transport by the *decree of the 30th October 1935* which made it necessary, as from the 1st February 1936, to obtain licences for private goods transport, the essential object of this decree, apart from certain safety regulations, being to impose duties upon vehicles used for such transport over long distances.

At the beginning of the present article we recorded, in the 3rd Supplement to the Enumeration of the legislative and administrative regulations, that in *Italy* a decree of the 2nd December 1935 imposes, also as from the 1st February 1936, taxes on road goods transport, both professional and private. As far as the latter is concerned, our second article (p. 135) called attention to the *law of the 20th June 1935* which requires such working to be licensed for registration purposes.

Other countries now considering the regulation of private road goods transport would no doubt find a brief description of the four above-mentioned attempts useful before our analysis of the *public* transport regulations is continued.

* * *

First of all we will endeavour to define the *scope* of such regulations from the point of view of the capacity of the vehicles used, their radius of action, and the kind of goods carried in them. We will then see if and how such regulations *discriminate between private transport operations according to their relations with the railway;* then we will examine the way the *regulations are intended to influence private transport* (administratively or fiscally). We will describe the attenuating provisions made for exceptions likely to affect the efficacy of the regulations in question, and we will analyse the « *working* » of the regulations examined.

Finally we will try to deduce from this examination the ultimate object of the laws in question.

* * *

1. The four series of regulations dealt with in this chapter differ in scope.

a) The *Austrian* regulations do not take *the capacity of the lorries* used into account. The *Czechoslavak* legislation only affects vehicles weighing more than 1 1/2 tons; the *French* legislation has not yet laid down any limits for the lorries liable to these taxes, but this is to be decided later. The *Italian* legislation only excludes small lorries of less than 100 kgr. (220 lb.) capacity.

b) From the *point of view of radius of action*, i. e. the distance for which the private goods transport is worked, the situation is as follows :

The *Austrian* legislation definitely forbids transport for distances of more than 100 km. (62 miles) if this is parallel to the railway (1), by the shortest route practicable for motor lorries between the consignment and delivery places, the distance to be measured between the administrative limits of these places.

The *Czechoslovak* legislation does not directly lay down any such limit. But, as we shall see later on, only private goods transport over distances of less than 30 km. (18.6 miles) will in practice be free from any restriction as to the capacity of the lorries used; this distance may perhaps be increased to 40 km. (25 miles). Motor transport worked with the object of bringing goods to the nearest railway station or to collect goods from this station is not limited to any distance.

The *French* legislation does not lay down any radius limit, but affects all transport worked outside the limits of a zone in which the operating headquarters or the offices of the « carrier » are located (for example the factory owning the lorry) and the neighbouring Departments. This increases the radius of action from 100 to 150 km. (62 to 93 miles) in many cases.

Nor does the *Italian* legislation specify any limiting radius of action; it excludes as a rule transport worked within a commune, transport worked between a commune and the station serving it, as well as transport normally worked by rural undertakings which is not worked outside the limits of the province in which the headquarters of the undertaking are situated, i. e. only worked for distances not exceeding 30 to 50 km. (18.6 to 31 miles) approximately.

c) As for the *kind of goods transported* in motor lorries in connection with the owner's business, the situation is as follows :

In *Austria*, transport worked by lorries specially and definitely designed for certain classes of goods, such as beer, ice, milk, bread, livestock, mineral oils, chemical products, etc., is outside the scope of the regulations.

For the *Czechoslovak* legislation please refer to point 4 below (attenuations).

The *French* regulations do not apply to vehicles belonging to public services nor to those used exclusively for post office transport, special vehicles used for funerals, as well as — this also applies to the safety clauses — transport by vehicles used by farmers to transport their harvest, if these vehicles are only used to carry the products from the place they have been harvested to that where they will be stocked or handled.

We mentioned above that the *Italian* legislation favours rural undertakings and their products from the point of view of radius of action.

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* *

2. We will now examine if these regulations *discriminate between private*

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(1) It was proposed to reduce this limit after the 1st April 1936, probably to 60 km. (37.3 miles).

transport operations according to their relations with the railway.

From this point of view the *Austrian* legislation distinguishes between transport worked between places linked up by one or several railway lines giving satisfactory economic communications and transport not worked in parallel with such railway services. We said above that the former are only free if the distance is less than 100 km. (62 miles). On the other hand, transport of the latter category, i. e. worked where there are no satisfactory railway services, appears to be completely free, even if the distance exceeds 100 km. (62 miles). It would appear, therefore, that the distinction is based on the criterion of satisfactory rail transport alone.

The Czechoslovak legislation makes no such geographical discrimination in the case of private transport, but as we shall see later on, is only intended to cover transport not worked in agreement with the railway.

The *French* legislation makes no such distinction, neither does the Italian.

As we already stated when examining the question of discrimination according to radius of action, the Czechoslovak and Italian regulations only cover private goods transport brought to a station to be carried by rail, and inversely goods collected from a station.

* * *

3. *The way in which the regulations in question are intended to affect private goods transport* also differs.

Apart from the *Austrian* legislation, which merely *forbids* transport parallel to the railway for distances exceeding 100 km. (62 miles), the regulations in question depend for their effectiveness on fiscal measures, thereby exerting financial pressure on private transport.

In the part dealing with taxation, the Czechoslovak law No. 77/1935 lays down that the traffic tax on lorries and tractors, based on their weight and capacity, is to be increased by 60 to 200 % (according to capacity) in the case of vehicles not used for professional transport, if the undertaking owning them has made no agreement with the railway about using motor vehicles for this undertaking, whether its own vehicles, vehicles hired by it, or worked for it by professional carriers.

The supertax is based on the following scale : If the tonnage of the lorry does not exceed 1.5 tons no increase.

	Supertax calculated in terms of the usual tax.
If the tonnage of the lorry is over 1.5 but does not exceed 2.5 tons.	60 %
If the tonnage of the lorry is over 2.5 but does not exceed 5.0 tons.	100 %
If the tonnage of the lorry is over 5.0 tons	200 %

The tonnage of trailers is to be added to that of the lorries. For example a lorry weighing 4 tons with a 2-ton trailer has to pay the tax plus 200 %.

In actuel figures this means that for a 4-ton lorry with a trailer carrying 2 tons, 12 390 Czechoslovak crowns will have to be paid for these two vehicles annually, whereas if an agreement had been made with the railway, only 4 130 crowns, would have to be paid.

This great difference may not prevent the use of motor vehicles by industrial or commercial firms for goods that could be carried by rail, but obviously will encourage them to make a reasonable and fair agreement with the railway.

In order to encourage agreements between the railway and the different firms using lorries, the taxes in question will not come into force till the 1st January 1937.

The *French* regulations merely state that private goods transport by road, worked outside given limits (see above) will be taxed.

The public administrative regulations are to fix the amount and conditions of these taxes. As these regulations had not been put into force by the 1st January 1936, the date of application of the decree had to be put off.

It is difficult to estimate in advance the result of these taxes.

The *Italian* regulations lay down definitely and clearly that, with the exceptions given above, all private goods transport over public roads and special motor roads must pay a tax of 0.8 centisimi per kilometre and per hundredweight (i.e. 8 centisimi per net tonne-kilometre). For example a 6-ton lorry worked 10 000 km. per annum fully loaded will have to pay a total of 4 800 lires. Unlike the method of the Czechoslovak regulations which are based on a *fixed* sum according to the capacity of the lorry, the Italian regulations make the amount of the tax correspond with the importance of the transport actually carried out. The Italian system hits regular long-distance transport. For example, if an industrial firm every working day (approximately 300 days a year) works a 6-ton lorry over a distance of 100 km. fully loaded on the outward journey and empty on the return journey, the total annual tax would be 14 400 lires. A firm with two 6-ton lorries in daily service over 250 km., so that the day's working was 6 × 250 or 1 500 net tonne-kilometres, would have to pay a total annual tax of 36 000 lires. The effectivenesss of this system in the case of regular long-distance transport is obvious.

* * *

4. The efficacy of the regulations examined depends to a great extent on the *attenuations* allowed in addition to those already mentioned.

In this connection, the *Austrian* legislation allows the Ministry of Commerce and Communications, in the case of proved demands, to grant exceptions to the 100-km. limit in the case of transport parallel to the railway if the special nature or particular conditions of the industry in question makes this absolutely necessary, either from a manufacturing point of view or from that of marketing the products.

In the case of the Czechoslovak legislation, we give hereafter the provisions on which are to be based the agreements between the railway and lorry owner whose lorries are used for private transport and who wishes to avoid paying the above supertaxes by making an agreement as to the use of the vehicles for his own needs :

The agreements must allow for exceptional cases, when goods have to be consigned in a hurry by inland water services, especially when the boat load will be completed in this way.

The contracting party entering into an agreement with the railway must not suffer any material prejudice as regards the speed of transport or the kind of handling required.

The agreements must favour rapid transport by rail or road in the case of foodstuffs to the markets, as the quality of such goods would suffer from any increase in the transport time.

The agreements must take into account the special needs of certain regions or certain branches of manufacture and commerce, as well as certain exceptional conditions individual to certain firms.

The text of the *French* regulations does not make it possible to foresee if the regulations which will fix the conditions under which the taxes are to be paid will include similar exceptions and mitigations, like those in Czechoslovakia, for example.

The *Italian* regulations leave it to the Ministry of Finance to decide, in agreement with the Ministry of Communications, the extent of the free zone, and notwithstanding the general regulation, extend or restrict this zone.

⁂

5. The « *working* » of the regulations considered is ensured by provisions on the registration of the vehicles concerned, verifications of the imposition of the taxes or supertaxes, control measures, and penalties.

For example the *Austrian* regulations require every lorry used for private goods transport to carry an official plate marked W. K. and another plate giving the name and headquarters of the owning firm. In the case of lorries which the Ministry of Commerce and Communications has exempted from the 100-km. limit for transport parallel to the railway, the sign W. K. must be completed by the sign « + 100 ».

The driver of the lorry or the man accompanying it must have a list of the goods carried, giving their class, the number of packets, the weight, and the consignee. These lists have to be kept for three years.

The authorities or their official representatives can at any time require the driver to produce the documents accompanying the goods transported and verify if they correspond with each other.

Infringements of the provisions of this decree are punishable by fines of up to 2 000 schillings or six months imprisonment. These penalties affect the owners and staff of firms using the lorries for their own business. If the offence is repeated the private goods transport worked by or for the offender can be forbidden by the competent authority.

Any action taken or agreement made to avoid or get round these regulations is null and void.

The basis of the *Czechoslovak* regulations is the provision made for agreements between lorry users and the railway.

a) In this connection it may be first pointed out that, according to one clause, the railway administration must enter into an agreement with anyone willing to promise not to use lorries for distances exceeding 30 km. (18.6 miles). In other words, lorry owners know that if they fulfil this condition they will not have to pay the supertax. We saw above (under 4) that this also applies, no matter what the distance is, if their lorries only collect and deliver goods to the nearest railway station.

b) The two parties who have drawn up such an agreement, in its essential parts, can demand as a condition of its enforcement that certain details about which complete agreement could not be reached, be settled by arbitration.

The arbitrators in question are to be three in number, one nominated by the Ministry of Finance, one by the Ministry of Railways, and the third either by the Ministries of Commerce or Agriculture in agreement, or if they cannot agree by whichever Ministry the Ministry of Finance thinks fit. In the case of transport worked by co-operative stores which come under the Ministry of Social Affairs, this latter Ministry appoints the third arbitrator.

The decision of these arbitrators is limited by the principles governing the drawing up of the agreements in question, as well as by the requirements of the two contracting parties. The decision is carried by a majority of votes ; if there is no majority the opinion of the Ministry of Finance's arbitrator is to be taken as representing that of all the arbitrators.

In the case of ligitation about agreements in force, the regulations contain provisions for arbitration on similar lines. Anyone who has acted as arbitrator in making an agreement cannot act in a similar capacity in lawsuits resulting therefrom. The decision of the arbitrators on the point contested has the value and effect of a legal sentence.

An order to be passed will lay down in greater detail how the arbitrators shall act in both cases.

d) The Czechoslovak regulations make no provision for any distinctive mark to be carried by lorries working private goods transport. However, the lettering to be used on lorries used for professional transport and transport worked by licence, laid down in the same regulations, indirectly distinguishes them from lorries used in private transport.

e) The collection of the supertaxes is simple in so far as it is merely added to the normal traffic tax. The owner of a lorry of over 1.5-ton capacity wishing to avoid the payment of this additional tax has to bring to the taxation office, with this traffic tax statement, an attestation from the railway administration that he has made an agreement with them about using motor vehicles for his own transport.

It should be noted that this agreement refers not only to the utilisation of vehicles belonging to the user, but also to hired vehicles and even to transport worked for him by professional firms .

f) Finally, the supertax, based on the traffic tax, does not apply to lorries newly put into service, up to the 31st December 1938, during the time they are exempt from the latter tax. Until now the period of exemption has been one year for petrol vehicles and three years for vehicles with diesel or producer-gas engines. Anyone therefore who only owns *new* lorries will not be affected by these regulations during the period they are exempt from taxation.

g) As regards control, the Czechoslovak legislation has left this in the hands of the State Railway Administration, which has to report infringements to the taxation control offices.

h) In addition, in every agreement on the utilisation of motor lorries for private goods transport, provision must be made for fines if it is infringed. The amount is three times what the contracting party would have to pay the railway for working the transport it has been unjustly deprived of.

The *French* regulations lay down that all vehicles used for private goods transport must clearly show distinctive marks front and back. Infringements of this regulation will be punishable by fines up to 100 francs.

The way the tax is to be paid will be fixed by an order to be passed.

Infringements of the regulations about payment of the tax are to be punished by fines of from 100 to 1000 francs; if the offence is repeated the lorry can be temporarily taken out of service (for periods of from one month to one year, according to the case) by the withdrawal of the licence.

The *Italian* regulations go into great detail about the way they are to be enforced.

All private carriers must enter in a register of approved type all transport worked for their own needs by the lorries they own. Each leaf of the register is to be divided into two parts (tear-off and counterfoil) which must be identical. The register is kept by the lorry owner.

The regulations lay down the entries to be made on the waybills and counterfoils, as well as the way the tax is to be collected.

Fines are imposed for infringements of these different provisions of the regulations.

If the offence is repeated, the licence can be withdrawn.

* * *

6. The *objects aimed at* by these regulations on private goods transport are much the same in every case.

Whether it is explicitely stated or not, they are all inspired by the idea that the development of private goods motor transport should be restricted if, because of its nature and extent, it has become a danger to the railway's part in the national economy.

The *Austrian* regulations, the oldest, though no explicit mention is made of the fact, are obviously inspired by the idea that traffic should be divided up between railway and road according to the principle that long-distance traffic should be worked entirely by rail, and other transport freely competed for by railway and road.

The *Czechoslovak* regulations, by introducing supertaxes on lorries whose owners have made no agreement with the railway about using the road for their business requirements, make it quite clear that « these agreements are intended to regulate the utilisation of motor vehicles so that the railway will retain such transport as will enable it to carry out all the duties imposed on it by the national economy, without any drastic alteration in its rates system ».

These regulations, as we have seen, do not try to achieve this result by authoritatively forbidding private transport parallel to the railway beyond certain distances, or by imposing a tax on all transport worked outside a given area. They have attempted rather to induce the lorry user to weigh the advantages of the motor against the cost and conditions of rail transport, threatening to put supertaxes on his lorries. Groups of such users (for example industries grouped according to their branch of manufacture) would be well within their rights in wanting to encourage the conclusion of individual agreements by laying down the general principles, and they are in a better position than an individual industrialist to appreciate the harmful effects on the industry itself if egoistical tendencies are allowed free play. An individual industrialist only sees the momentary profit to be obtained from the use of motor vehicles; he thinks he has a perpetual right to the benefits he obtains from the railway rating system and takes no heed of the future nor the effects his policy can have for himself and his like.

The agreements considered above are an improvement on the system in force for some years, i. e. the system of agreements between the railway and different industrial groups to limit motor transport.

Such agreements could only have a limited scope; they were based on rating reductions for the transport of raw materials, coal in particular, and as a rule their only result was to limit the use of motor vehicles in the case of such goods. Certain special rates very widely applied (for example special rates for small coal, wood, and beet) were subject to a clause specifying that firms wishing to benefit by such special rates had to make an agreement with the railway about using motor transport. Thus mining firms wishing to profit by the special rate for coal had to promise only to sell coal on condition that it would be carried by railway, except immediately round the mines (within 30 km. = 18.6 miles, for example).

The above mentioned agreements and those provided for in *law No. 77/1935* should be co-ordinated.

The preamble to the *French regulations* contained in the law of the 30th October 1935 on the licensing of private goods motor transport, which refers on the one hand to former legislation on co-ordination of transport, and on the other to the law of the 8th July 1935 on the steps to be taken to save the franc, brings out the objects aimed at by these regulations. It must be admitted that not only is there a tendency to extend the idea of co-ordinating railway and road now current in the sphere of public transport to private transport likewise, but attemps are also being made to find some way of making good the deficit in the railway receipts due to the development of motor transport, the greater part of which must be accepted as the inevitable result of dividing the traffic between the two methods of transport on which such co-ordination is based.

As for private goods transport, this apportionment is generally based on the principle that only long-distance transport belongs by its nature to the railway. The zone consisting of the province in which the headquarters office of the haulier are located and the neighbouring provinces often extends the sphere of action of private lorries *exempt from the tax* to 100 km. (62 miles), and even to 150 km. (93 miles) or more.

75 % of the taxes go to the Treasury and 25 % to the provincial authorities. The 75 % portion is obviously intended to help the Treasury to meet the deficits of the Main-Line Railways, whereas the 25 % will be devoted to the maintenance of the provincial roads in the region in question.

The regulations make no stipulations about the railway rates.

Mention should be made, however, of the decree of the 28th October 1935 on the conditions under which the Main-Line Railways can be dispensed from their specifications and agreements. According to this decree, the railways can make agreements with one or several consignors or consignees granting special goods rates and conditions other than those generally in force, adapted to the particular needs of the consignor or consignee.

These agreements appear to be somewhat similar to the Czechoslovak railway regulations mentioned above.

The preamble of the *Italian* regulations refer to the law of the 20th June 1935, which only deals with professional or public transport, apart from the regulations on the obligation to get a licence for private goods transport and to mark with a special sign the lorries used for such transport. Apart from this the object of these regulations would appear to make it quite clear that they stress the need and urgency for « putting some sort of order in the cost of goods transport (disciplinare i prezzi dei trasporti delle cose) ». No attempt is made to achieve this end by the methods used in Germany, for example, in the case of professional transport by a minimum limit on the rate for distances of over 50 km. (31 miles) according to the special regulations issued by the Ministry of Communications to protect the railway.

As we have seen above, this tax can be entirely prohibitive in the case of regular transport over long distances worked by large-capacity lorries which are also used on the return journey, and so the traffic is brought back to the railway.

Although protection of the railway is not explicitely mentioned in the text of the Italian regulations, it would appear to be one of the essential objects.

Mention must be made of two of the clauses the insertion of which in this law shows that there is a relation between them and the imposition of taxes on motor goods transport.

Mention will first of all be made of clause 15 of *law No. 2097 of the 2nd December 1935* :

The Minister of Communications is authorised to provide and include in his budget funds for the following purposes :

a) Subsidies to railways, tramways, inland water services conceded to private undertakings, and public motor services (passenger and goods), trolleybus lines and cable railways.

b) Additional temporary subsidies for the operation of railways, tramways, inland water services, conceded to private undertakings, and premiums to goods transport firms worked by motor lorry acting as feeders to the railway;

c) Application of the decrees of the 2nd August 1929 (law of the 22nd December 1930) and 14th October 1932 (law of the 8th May 1935) also relating to subsidies and other measures intended to meet the crisis in transport conceded to private industry (*).

The ordinary subsidies, the additional operation subsidies, and the premiums granted under *(a)*, *(b)* and *(c)* of the first paragraph shall be granted annually, or as a capital sum, by the Ministry of Communications in agreement with the Higher Council for Public Works.

Although not explicitely stated, it can be understood from this text that the revenue from the taxes on motor goods transport is intended to finance the above funds.

The other provision is to be found in clause 16, and is worded as follows :

By decree, published in agreement by the Ministry of Communications and the Mi-

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(*) *Explanatory note.*

Point b. — The additional operation subsidies are granted for limited periods of crisis with the object of getting over temporary working difficulties, in the case of services of national or regional interest, provided that everything possible has been done to simplify the working.

Point c. — The decree of the 2nd August 1929 fixed the maximum limit at 50 000 lires per kilometre a year for 50 years, in the case of railways of regional interest conceded to private enterprise, and at 35 000 or 20 000 lires in the case of local railways.

In addition, the State can allot up to 8 000 lires per kilometre a year to new electric railways, and up to 10 000 lires per kilometre a year, for 50 years, for the adoption of electric traction or other types of traction on old steam railways.

The decree of the 14th October 1932 confirmed in the case of railways and tramways the authorisation to change the method of traction, or to replace such lines by motor services or trolleybuses, the State subsidies to be reconsidered in such cases.

nistry of Finance, the rates in force on the State Railways, private railways, and tramways outside towns, for the transport of goods and post parcels can be modified, according to the regulations laid down in the present decree.

All concessions and special agreements about temporary goods rates reductions (inland), even those for periods of more than a year, are to be declared null and void when the present decree comes into force.

No compensation or damages can be claimed on account of this cancellation.

The modifications in rates mentioned in the above clause were in fact made immediately afterwards by the Royal decree of the 9th December 1935 introducing a general increase in the goods rates on the Italian State Railways. This decree which added supertaxes to the existing rates refers explicitely to the decree of the 2nd December 1935.

The amount of the supertax varied between 10 and 35 % of the existing rates.

This general increase in railway rates naturally lessened the effect of the introduction of taxes on road goods transport.

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CHAPTER FOUR.

Right of State monopoly in the case of motor transport.

None of the regulations examined is more clearly inspired by the idea that the organisation of public motor transport should be a State monopoly than the *Rumanian*.

Legislation in other countries only reserves to the State the right to authorise the organisation of public services by various undertakings. Even if the word « concession » is used, it must not be taken to mean the *handing over* of a State privilege or monopoly, except in Hungary with which we shall deal later on. The preamble of the Czechoslovak law of the 23rd December 1932 lays particular stress on the fact that the law is not based on the idea of a State monopoly of public road traffic. Such legislation is mostly inspired, on the contrary, by principles similar to those of the laws on professions in general, certain regulations or clauses of which also regulate commercial motor transport and the firms organising it.

Point 1 of the *special Rumanian law of the 15th October 1932* (point 1, first article, p. 553) defines the monopoly mentioned above as follows :

The *organisation* of public road haulage service, outside municipal boundaries, by mechanical vehicles which do not run on rails, for passengers, luggage or goods, is recognised as a State monopoly, and will be *carried out* by the Ministry of Public Works and Communications.

The same law gives towns or municipalities a like monopoly within their own boundaries.

Clause 2 of this law provides for the *working* of the above monopoly by the State Administration on the principles laid down in another law on the organisation and management on commercial lines of public undertakings and property.

Clause 3 is intended to elucidate the question whether the word « working » in the previous clause means the operation of public services by the State, as it might at first sight seem to do, or if a different meaning is to be given to it. Clause 3 is worded as follows :

The *concession* of the right to operate road services over various routes is publicly contracted out (after tender)... for a maximum period of five years.

Later on in clause 4 it is stated :

> If a public haulage service is operated under concession, all the rights of the monopoly belong to the concession-holder for the whole period of the concession...

The *standard specifications* (see point 1, first article, p. 553) which replace the regulations for the application of this law state explicitely, in clause 4, that : « the concession deed by which the route was publicly contracted out to the concession-holder gives him the right to the *exclusive* operation of services on this route ».

The operation of public motor services *by the State itself* is nowhere dealt with, even conditionally, either in the law or in the standard specifications mentioned above.

It will be seen, therefore, that the working of the monopoly in question must be understood in another sense, i.e. commercially or rather financially, as also appears from the regulations in clause 5 of the law requiring the Administrations entrusted with the construction, upkeep, modernisation and administration of the public roads to have a share in the *receipts accruing from the use of the respective roads,* in conformity with clauses 19*a* and 28*b* of the road law of the 20th April 1932.

The first of these clauses stipulates that the revenue derived from the use of the national roads by public motor services be reserved for the General Road Management Fund. Clause 28 lays down similar conditions in the case of provincial and local roads.

The standard specification, in its clause 62, is still more explicit. It says that the annual tax payable by the concession-holder is paid *in return* for the use of all the monopoly rights given him by the concession.

The special law of the 15th October 1932 fixes these amounts in terms of the mileages and capacity of the vehicles used.

Finally, it should be noted that according to this law, the State Railways and Post Office Administration are in the same position as private firms when organising road services and like them depend on a public contract (after tender).

However, the *Rumanian law of the 21st July 1934* (first article, point 4, p. 553) made an essential alteration to this regulation, by authorising the Minister of Public Works and Communications to grant the Rumanian State Railways the exclusive operation of public transport services over certain roads, *without public auction.*

On these sections the State Railways will consequently have a sort of monopoly of public transport. This is explicitely laid down in the Agreement made in August 1934 (first article, point 4, p. 553), in these words :

> The Ministry of Public Works and Communications grants the Rumanian State Railways the exclusive right to operate the *monopoly* of public passenger, goods and luggage transport on the sections of road listed in the appendix.

The *special Hungarian law No. XVI/1930* contains, under clause 5, a similar regulation to that in force in Rumania :

> The organisation and operation of public motor passenger and goods services over fixed routes and following fixed timetables between towns, is reserved to the State. The use of this right can be temporarily handed over to private firms, according to the regulations given in the present law. In so far as the Government wishes to

make use of this right and make contracts with the firms in question, the said contracts shall be brought to the notice of Parliament. The organisation and operation of other public motor services (for example occasional services) also require a concession.

The Hungarian State does not operate motor services; according to this law regular services must obtain a concession like that required for occasional services, so that the above regulations only imply that the State can hand over the privileges it has reserved for itself in this connection.

It would perhaps be as well to mention the case of *Switzerland* where the *Federal law on the Post Office services of the 2nd October 1934* gives the Post Office Administration « the exclusive right to transport passengers by means of regular services, in so far as this right is not restricted by other federal laws ». Clause 3 of the same law lays down that « Concessions for regular passenger transport services can be granted to professional transport undertakings ».

The Post Office Administration makes full use of this exclusive right by itself operating regular services; there are very few services of this kind worked by private concession holders.

In the case of public *goods* transport services with fixed routes and timetables, the *law of the 23rd January 1934* (first article, point 5, p. 554) indistinctly requires a concession to be obtained, without conferring any exclusive rights to such services as in the case of *passenger* transport.

[621. 43 . (43) & 625. 258 (.43)]

Electro-magnetic rail brakes as fitted to the German high-speed railcars,

by Reichsbahnoberrat RECKEL, Dipl.-Ing , V.D.I., Berlin-Steglitz.

(Glasers Annalen.)

The author, as a result of the tests on the value of the coefficient of adhesion between wheel and rail, shows that in the case of high-speed vehicles, the compressed-air brake should be completed by the electro-magnetic rail brake. He gives the conditions an efficient magnetic rail brake should comply with, and describes the method of fitting such brakes to the Reichsbahn high-speed rail motor cars.

The Grunewald brake testing section recommends that, in brake calculations, the coefficient of adhesion between rail and wheel μ_s be taken as below 0.15 if the wheels are not to be skidded. For a given speed, the actual adhesion factor cannot be given a definite numerical value, as the points on the graph obtained under identical conditions, with a dry rail for example, differ very widely. In order to show graphically the many values recorded, it was necessary to draw a group of curves (1). To quote some figures, on dry rails the minimum value of μ_s was 0.17, and the maximum 0.26. The extreme lines of the group of curves are parallel and increase almost imperceptibly with the increase in speed. When $\mu_s = 0.15$, the margin of safety against the wheels picking up is still quite large in most cases. Under unfavourable atmospheric conditions, however, be it remembered (rain, fog, hoar frost, etc.), the value may fall to 0.08.

Using the value $\mu_s = 0.15$ throughout the brake application, the mean retardation p_m so obtained equals $9.8 \times 0.15 = 1.47$ m. (4.8′) per $\overline{\text{sec.}}^{2}$ When a train is stopped from a speed of 160 km. (100 miles) an hour in 700 m. (765 yards), allowing a small safety factor, the mean retardation over the whole braking period is $p_m = 1.57$ m. (5.14′) per $\overline{\text{sec.}}^{2}$ and when in 1 000 m. (1 093 yards) is still as high as 1.1 m. (3.6′) per $\overline{\text{sec.}}^{2}$.

Such high average retardations throughout the whole braking period are impossible with the block brake and ordinary simple gear at such high speeds, as the coefficient of friction between the brake block and the tyre is very low and only increases as the speed falls, slightly at first, and more and more afterwards.

To prevent the wheels skidding at low speeds, the vehicle must be either braked lightly at first, or the initial braking effort must be reduced uniformly or gradually for given speeds according to the variations of the friction coefficient, and at such a rate that the brake block pressure is always smaller than the adhesion available between block and rail. So far the maximum retardation on long trains running at more or less high speeds with brake blocks has not exceeded 1 m. (3.28′) per $\overline{\text{sec.}}^{2}$.

However, the most recent design of shoe brake (the SS type), characterized by a high friction coefficient, large brake blocks, rapid rise of pressure in the brake cylinders, and high brake propagation speed, has already given retardation figures closer to the values calculated from the admissible adhesion value given above.

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(1) Cf. B Metzkow, *Organ für die Fortschritte des Eisenbahnwesens*, 1934, Vol. 71, p. 247.

If a higher retardation such as the 1.57 m. (5.14′) per $\overline{\text{sec.}}^2$ mentioned above is wanted, other braking methods not depending on the coefficient of adhesion must be used.

When brakes with drums or discs with special linings are used, a more uniform braking action with lighter and simpler brake gear can be obtained. With such brakes, however, a supplementary brake is desirable in order to reduce the braking period and distance and thereby protect the brake linings from over-heating.

The electro-magnetic rail brake provides a satisfactory solution of this problem, which has been widely used for a long time on electric tramways in hilly districts. The conditions in this case are particularly favourable to the use of this type of brake as the problem of exciting and feeding the brake electro-magnets is a simple one and their suspension does not cause any difficulties. As the brake is often used at every stop, the appreciable weight of the equipment and the expenditure it represents can be justified. On the Reichsbahn, the magnetic rail brake has been fitted only on the high-speed railcars which must be stopped in a short distance from a speed of 160 km. (100 miles) an hour.

The design and fitting of magnetic rail brakes to standard-gauge railway rolling stock presents certain difficulties apart from the high speeds, because of the very restricted space left on the motor bogies by the large motors for the electro-magnets, which reduces the accessibility of the component parts.

Particular attention should be paid to the following conditions and experimental facts hereafter :

1. Paragraph 28 of the regulations applicable to the construction and operation of railways lays down that the parts of the brake acting directly on the rail, such as the electro-magnets of the rail brakes can, when applied, come down onto the rail provided they are fitted in between the outer axles and, on curves, lie within the space swept by the tyres. When the brake is not in action the electro-magnets must be at least 55 mm. (2 3/16 ″) above rail level, and the above mentioned requirements as to their location be observed. As the tyres can wear 35 mm. (1 3/8″) and as the springs may deflect 40 mm. (1 9/16″), the electro-magnets must be fitted at least 130 mm. (5 1/8″) above rail level and strongly held in this position.

Such conditions obviously can be met only by special arrangements.

2. As the limiting position of the electro-magnets when lowered is fixed and must be absolutely worked to on account of the check rails, points and crossings, the design of an efficient electro-magnet becomes very difficult. Powerful coils and sturdy yokes for setting up the magnetic field are not easy to make.

3. At high speeds the faces of the brake pole pieces which slide on the rails become very hot. The parts have to be made so that heavy wear, hollow faces, warping, and other defects can be made good easily.

4. At high speeds the braking effort decreases, as the magnetic field sets up in the rail eddy currents which reduce the magnetic braking force. This effect is the much more serious that, at high speeds, the coefficient of friction of the steel pole pieces also falls off considerably.

5. The safety devices and signalling equipment along the line such as pedals and stops placed close to the rails can be affected by the electro-magnets themselves or by eddy currents set up in the rail.

These conditions were complied with when the scheme was in hand, and also on the test bench. The Jores-Müller magnetic rail brake, and control, as designed and built by Knorr Bremse A.G. for the Reichsbahn high-speed railcars, in its present form is entirely reliable. This statement is confirmed by the experience obtained with the first high-speed railcar (the « Flying Hamburger »), which has been in regular service more than two years and has run over 300 000 km. (186 000 miles).

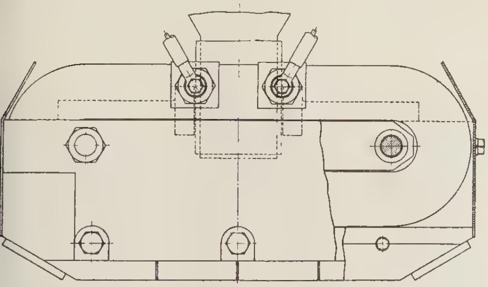

Fig. 1. — Brake electro-magnet. — Elevation.

The brake electro-magnets in general design only differ in minor points from those used in tramways. The track magnet (fig. 1) in cross section is horseshoe shaped as the magnets in figure 2. show. The free ends of the arms carry the special mild-steel pole pieces or shoes which, on the brake being applied, rub on the rail. These pole pieces are attached to the arms of the magnets by means of studs and adjusting washers so as to take the load off the holding bolts. The windings round the middle part of the body of the magnet are protected against mechanical damages and especially against dirt and moisture. Care has been taken to prevent leakage and sparking at the leading-in points of the wirings. The pole pieces are as wide as the rail head allows, which gives a better efficiency per unit of length of magnet. The table below gives the leading dimensions and power of the electro-magnets to suit the requirements of the standard-gauge permanent way.

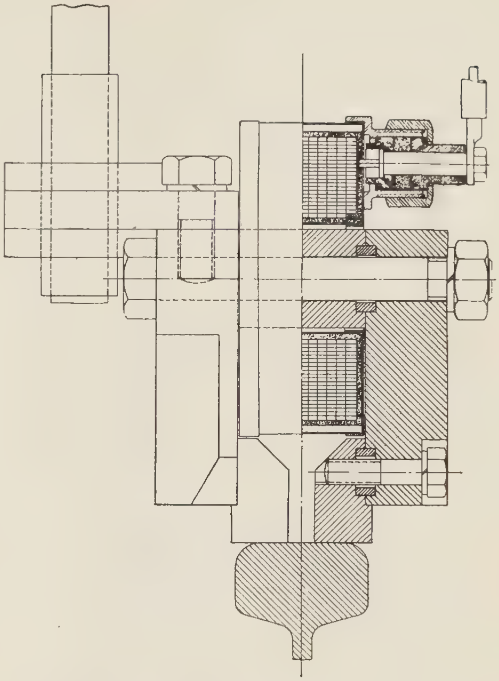

Fig. 2. — Brake electro-magnet. — Section.

Although the shape the magnet has to be made does not cause any particular difficulty even up to lengths of 1.50 m. (4′ 11″), the tests prove that the pole pieces have to be adapted to suit the high speeds and the heating resulting therefrom. Cast iron brake blocks, which are relatively short, tend to get out of shape as a result of the alternative heating and cooling, and the pressure it exerts against the tyre varies in consequence. The pole pieces also, in spite of the way they are secured, get warped, and out of shape in the vertical plane. The result is that the bearing of the shoe on the rail top, never particularly good, through the incessant change in the rail head section, becomes worse.

Type of electro-magnet.		Length.		Width.		Height.		Braking pressure, the electro-magnet fully in contact on an even surface.	
		mm.	*inches.*	mm.	*inches.*	mm.	*inches.*	kgr.	*lb.*
DSp	70	800	*31.50*	153	*6.02*	246	*9.68*	5 600	*12 350*
D	75	870	*34.25*	146	*5.75*	218	*8.58*	6 000	*13 230*
D	100	1 120	*44.09*	146	*5.75*	218	*8.58*	8 000	*17 640*
D	125	1 370	*53.94*	146	*5.75*	218	*8.58*	10 000	*22 050*
DD	75	880	*34.65*	150	*5.90*	222	*8.74*	6 700	*14 770*
DD	80	930	*36.61*	150	*5.90*	222	*8.74*	7 200	*15 880*
DD	85	980	*38.58*	150	*5.90*	222	*8.74*	7 650	*16 860*
DD	90	1 030	*40.55*	150	*5.90*	222	*8.74*	8 100	*17 860*
DD	100	1 130	*44.48*	150	*5.90*	222	*8.74*	9 000	*19 840*
DD	105	1 180	*46.46*	150	*5.90*	222	*8.74*	9 400	*20 720*
DD	110	1 230	*48.43*	150	*5.90*	222	*8.74*	9 900	*21 830*
DD	115	1 280	*50.40*	150	*5.90*	222	*8.74*	10 300	*22 710*
DD	125	1 380	*54.33*	150	*5.90*	222	*8.74*	11 200	*24 690*
DD	135	1 480	*58.27*	150	*5.90*	222	*8.74*	12 000	*26 460*
DD	150	1 630	*64.17*	150	*5.90*	222	*8.74*	13 500	*29 760*

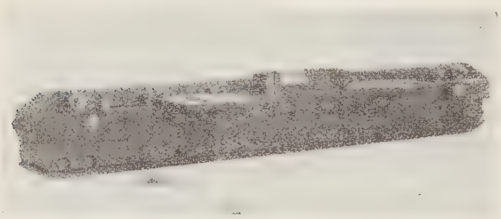

Fig. 3. — Brake electro-magnet (DD 125 type).

With the shoes mentioned above (fig. 3) and at 90 km. (56 miles) an hour, the average coefficient of friction obtained was only 0.04. This value increases as the speed falls (0.07 at about 50 km. = 31 miles an hour; 0.13 at about 10 km. = 6.2 miles an hour). The slope of the curve follows that of the cast iron brake block, but the values are higher thanks to the better contact (¹).

The brake action is improved by using lamellated pole pieces as illustrated in figure 4. The blades of the shoe still get out of shape to some extent, but not sufficiently to matter. Tests with much subdivided shoes have given better results, the improvement being as much as 20 %. With such shoes the coefficient of friction is 0.06 at 90 km. (56 miles), 0.09 at 50 km. (31 miles), and 0.155 at 10 km. (6.2 miles) an hour.

These findings show that in this case, as with cast iron brake blocks, the specific pressure of the surfaces in contact affects the value of the coefficient of friction. When the pressure is high, the coefficient of friction is low; if the pressure is reduced by suitable methods,

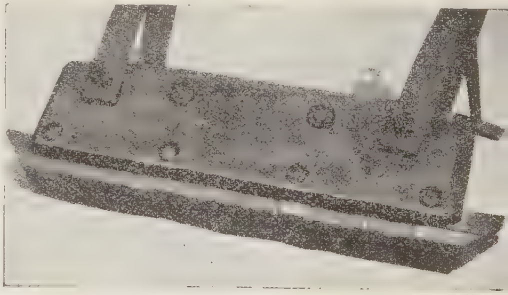

Fig. 4. — Brake electro-magnet with lamellated pole piece (trial design).

(¹) Cf. B. METZKOW, *Glasers Annalen*, 1927, special number, p. 137.

the braking effort is improved. If immediately it is applied the brake magnet makes good contact with the rail, or in other words if contact is made at many points, the brake action is better for the same current consumption. Moreover, when the pole pieces are properly applied, the magnetic flux can flow more freely and more strongly through the rail.

We have already pointed out that the magnets must be designed to bridge interruptions in the continuity of the rails, especially at points and crossings. Short magnets may catch in the gaps if not properly suspended. To make it easier to take the nose of the crossings and ensure the magnet is raised before the gap, the shoes are fitted with the specially tempered striking plates shown in figures 1 and 3.

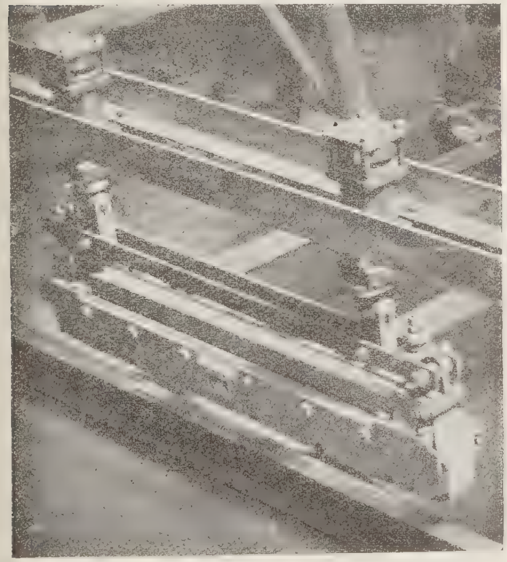

Fig. 5. — Suspension of electro-magnets (trial arrangement).

The iron pole pieces can be renewed easily; when the nuts have been slackened the pole piece can be withdrawn clear of the adjusting washers and dropped.

For safety reasons the track magnets are carried in duplicate under a frame built up of flat bars (fig. 5).

The spring suspension gear is the main one. The object of the additional supporting links is to hold the magnets in the raised position in case the spring gear breaks and so prevent them falling

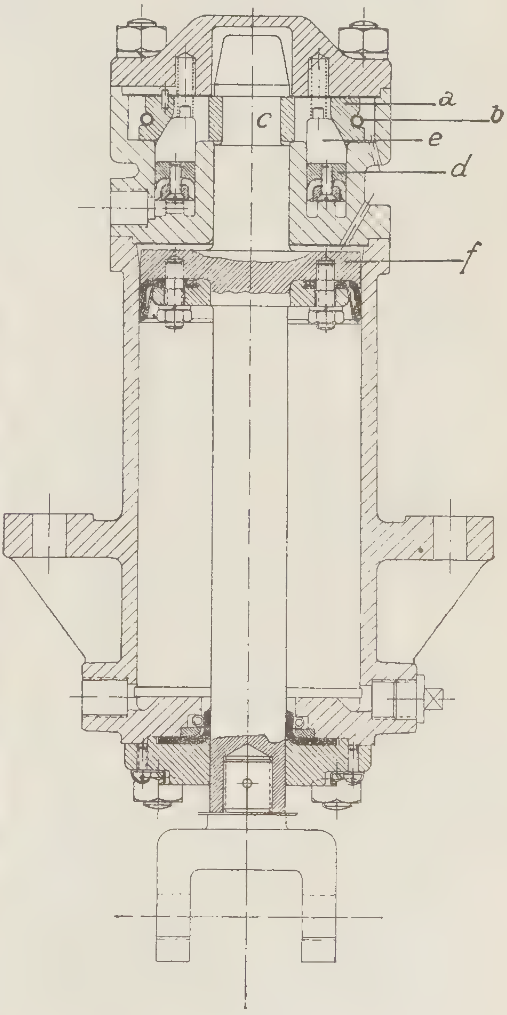

Fig. 6. — Brake magnets lifting cylinder.

onto the rail. A long oblong hole is cut in the links to ensure the spring gear being in action under normal conditions. The carrying frame is suspended through universal joints to the piston rods of the lifting-cylinders.

The lifting cylinder has to be designed for a piston stroke of 130 mm. (5 1/8″) to ensure the electro-magnets being at least 55 mm. (2 3/16″) above the top of the rails. Figure 6 is a section through the lifting cylinder. A feature to be noted is the holding device fitted on the lifting cylinder itself. This device is intended to hold the electro-magnets in the up position without the piston being under air pressure, in order to preserve the piston packing. The holding device consists of a disc *(a)* made up of a number of pieces divided on radial lines held together by a garter spring *(b)*. When the electro-magnets are lifted, the parts of the holding disc engage in a groove *(c)* turned on the tail rod. These parts are released by a piston *(d)* with wedge-shaped extension pieces *(e)* which enter the uniformly tapered recesses in the holding up pieces *(a)*. On admitting compressed air this piston rises and opens the holding-up pieces and liberates the lifting piston *(f)* which then falls under the weight of the magnets. When the lifting piston rises, the holding pieces are forced outwards by the coned end of the tail rod and only come together when they fall into the groove in the tail rod.

The brake magnets are raised and lowered by compressed air taken from the supply available on each railcar. The compressed air supply to the lifting cylinder and holding up device is controlled by an electro-pneumatic distributor and release valve fitted after the distributor. Figures 7 to 9 show the layout and combined working of these fittings. On cars built to date, the electro-pneumatic brake is additional to the compressed air brake and is only used for high-speed and emergency applications. When the driver makes a high-speed application the driver's brake valve is put to the desired position and a spring switch is closed automatically by a stop in the said driver's valve.

The coil of the electro-pneumatic distributor (1) is excited (fig. 7) and causes the armature *(g)* to drop, overcoming in so doing the pressure of a spring *(h)*. This opens the valve *(i)* which allows the air to escape from the reservoir *(l)*, constantly maintained under pressure, through the passages behind the large piston of the set of differential pistons *(k)* in chamber II. The set of pistons *(k)* with the small slide valve *(e)* is reversed and the compressed air enters under the releasing piston *(d)* of the lifting cylinder (3) and behind the

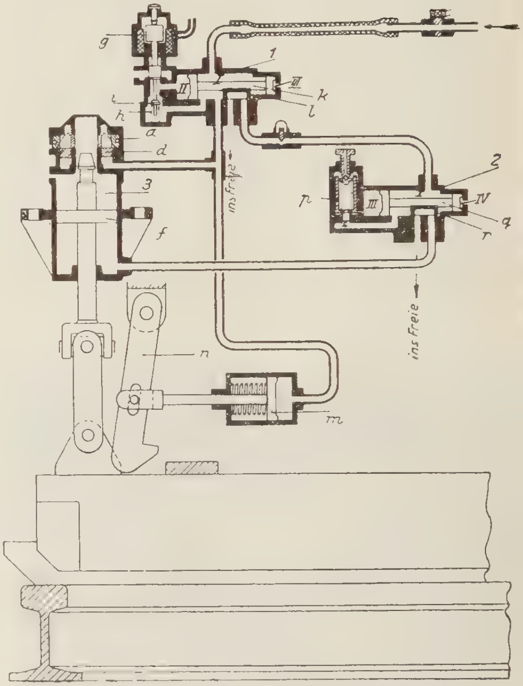

Fig. 7. — Electro-magnetic rail brake control. Application position.

Note: Ins Freie = to atmosphere.

piston *(m)* which controls the catch *(n)*. The pieces of the holding disc *(a)* separate, the catch is disengaged, and the lifting pistons *(f)* can fall as the release valve (2) allows the air to escape from the lifting cylinder. As the control current circulating in the high-speed application position has at the same time excited a brake contactor which feeds current to the windings of the brake electro-magnets the magnetic rail brake then exerts its full force.

When the driver's brake handle is moved from the high-speed position, the control current is cut off at the spring switch. The electro-pneumatic distributor (1) thus no longer receives current (fig. 8) so that the valve *(i)* with the armature *(g)* is forced upwards by the spring *(b)*. Chamber II is then released and the set of pistons *(k)* with the slide valve *(l)* can change over. The compressed air now passes through the release valve (2) under the lifting piston *(f)*; the holding-up cylinders are put into communication with the atmosphere and the pistons *(d)* and *(m)* are restored by the spring to their initial position.

When the lifting piston *(f)* has again risen to the top of its stroke and the holding device is engaged, the pressure under the hollow-spring-loaded piston valve *(p)* has risen sufficiently in chamber II to raise this valve. The compressed air now flows through the release valve (2) behind the large piston in chamber III and forces the set of pistons *(g)* with the slide valve *(r)* over to the right so that ultimately no compressed air is left in the lifting cylinders (fig. 9). The electro-pneumatic

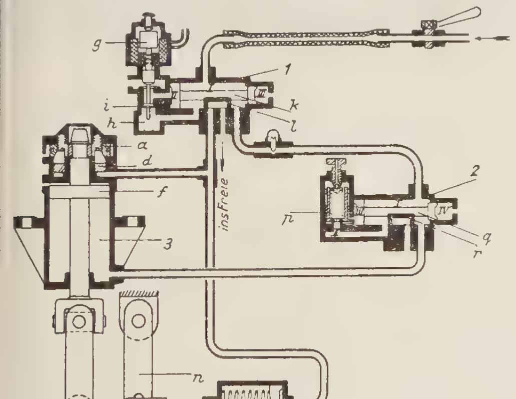

Fig. 8. — Electro-magnetic rail brake control.
Release position.

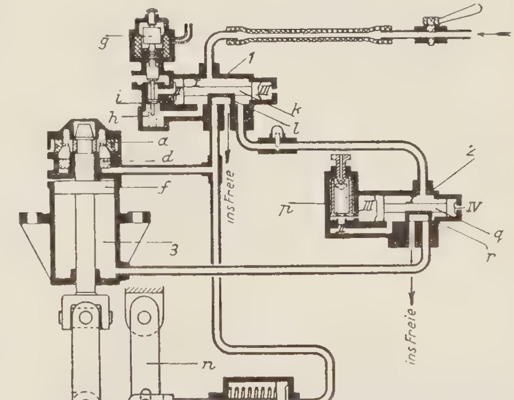

Fig. 9. — Electro-magnetic rail brake control.
Running position.

distributors are shown in section in figure 10, and the air release valve in figure 11. The above description of the valve gear makes any further particulars of the design of the parts unnecessary.

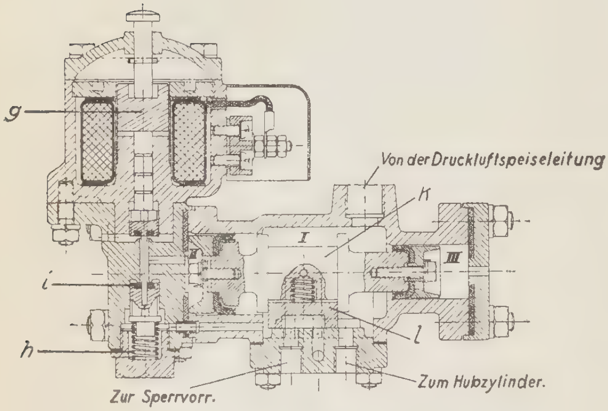

Fig. 10. — Electro-pneumatic distributor (longitudinal section) for controlling the magnetic rail brake.

Note: Von der Druckluftspeiseleitung = from compressed air train pipe. — Zur Sperrvorr. = to the holding-up device. — Zum Hubzylinder = to the lifting cylinder.

The tension of the spring in the hollow valve *(p)* of the air release valve can be altered by a screw so as to be certain this valve only lifts off its seat when the electro-magnets are fully raised, and held in this position by the holding up device.

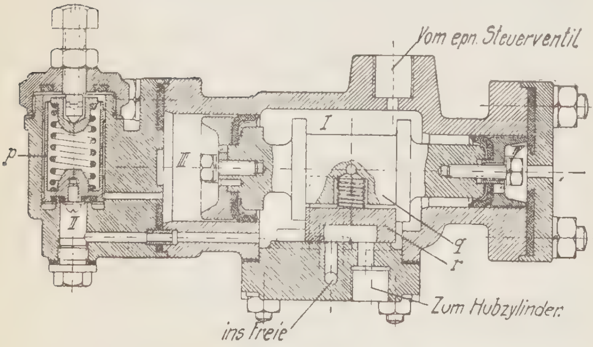

Fig. 11. — Air release valve. Longitudinal section.

Note: Vom epn. Steuerventil = from the electro-pneumatic distributor. — Ins Freie = to atmosphere.

Figure 12 shows the carrying bogie with magnetic rail brakes as fitted to the 2 × 410-H.P., Hamburg type, high-speed (100 miles an hour) railcars with the side screens raised. The two magnets with their carrying frame can be seen, as well as the electro-pneumatic distributor.

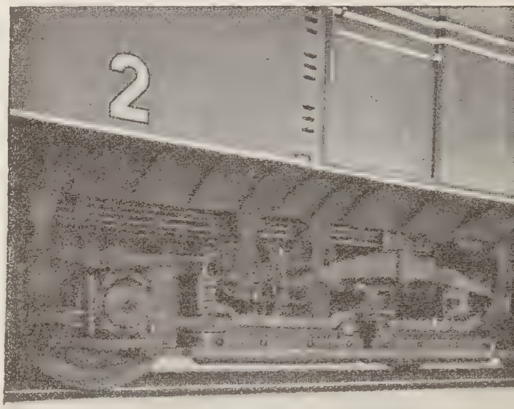

Fig. 12. — Motor bogie of the 2 × 410-H.P. 100-m.p.h. articulated railcar (Wumag-Görlitz type) ready for service.

Figure 13 shows the same bogie during erection. This view also shows the air discharge valve on the bogie sole bar, the suspension gear connected to the piston rod through universal joints, and the additional catches with their compressed-air cylinders. The guiding of the electro-magnets in the horns secured to the bogie should also be noted and also the way they are reinforced by sturdy cross braces. The side shock absorbers fitted to prevent the magnets oscillating in the transverse direction are also visible.

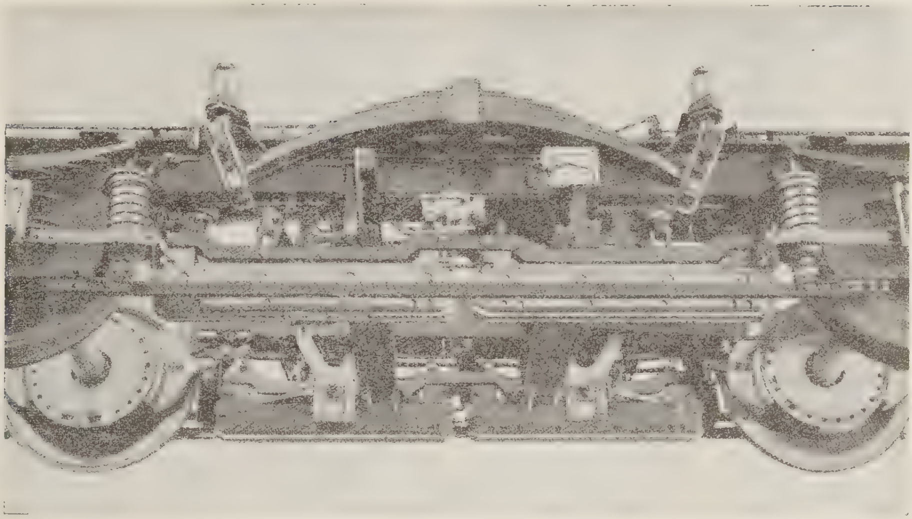

Fig. 13. — Motor bogie of the 2 × 410-H.P. 100-m.p.h. articulated railcar (Wumag-Görlitz type) under erection.

Figure 14 shows the general arrangement of the magnetic rail brakes on the same high-speed railcar; the same layout has been followed on other high-speed railcars of different types now being delivered or under construction.

The two outer bogies of the Hamburg type of high-speed railcar are fitted with 4 electro-magnetic brakes *(1)*, 1 m. (3′ 3 3/8″) long, and the middle motor bogie with 2 brakes *(2)* 1.25 m. (4′1 13/64″) long. As the electro-magnets have a particularly intense excitation (DD type), the total pressure of all the electro-magnetic brakes amounts to 99 t. (97.4 Engl. tons). The electro-magnets of the end bogies cannot be lowered accidentally, first of all because of the holding-up device in the lifting cylinders *(3)*, and secondly because of the special catches *(15)*. These latter were considered unnecessary on the middle bogie, as here the electro-magnet is held by two lifting cylinders and so is held up by two holding-up devices.

In the compressed-air connections to the lifting cylinders are fitted retaining valves with grooves *(4)* to slow down the descending movement of the magnets towards the end of their travel so as to soften their contact with the rail.

The arrangement of the electro-pneumatic distributor *(5)* and the release valve *(8)* and their incorporation in the equipment have been dealt with above.

The special fittings required in connection with the rail brakes include the brake contractor *(9)* which is also excited when the driver's valve *(16)* is put to the high-speed brake position and feeds the electro-magnets *(1)* and *(2)*.

An ammeter *(14)* and a marker lamp *(13)* to show the driver that the electro-magnets are in the circuit (in lowered position with sufficiently intense current) are also provided. This indication is useful after the magnetic brake has been used to stop the unit, in order to prevent the current being left on too long whilst standing and so discharging the battery *(11)*. *(10)* is the compressed-air switch of the control current,

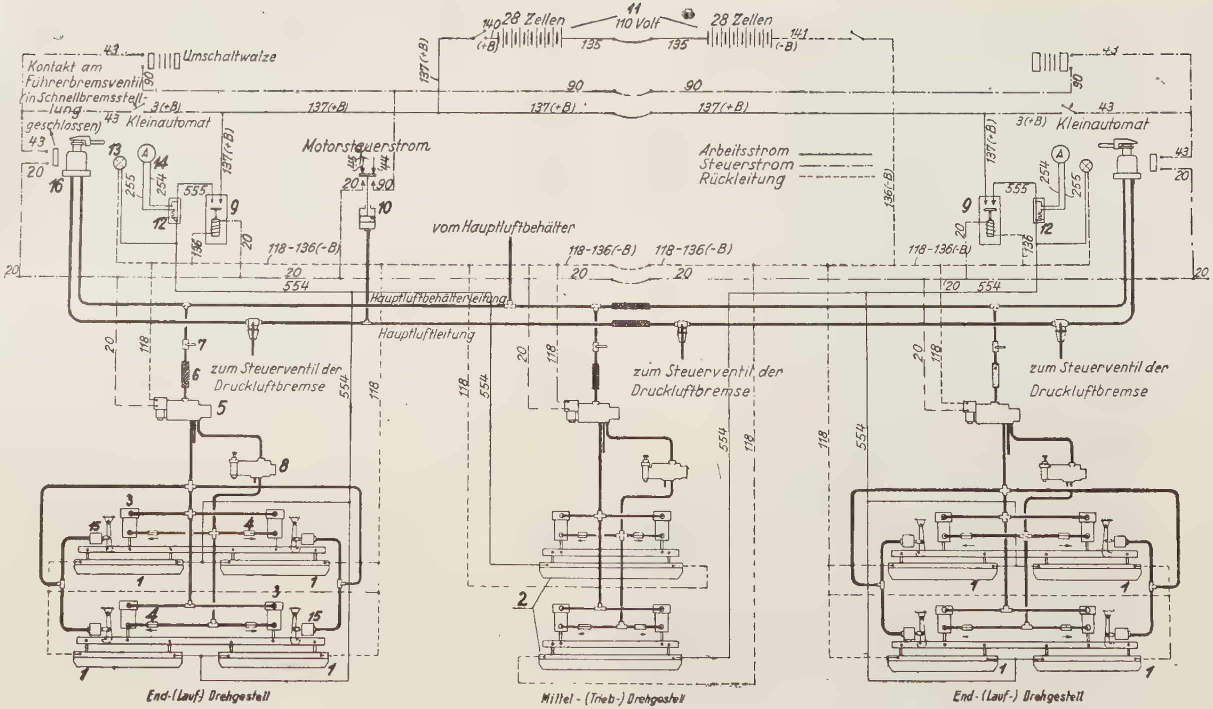

Fig. 14. — Wiring diagram of magnetic rail brake on the 2 × 410-H.P. high-speed (100 m.p.h.) Hamburg type railcar.

Explanation of German terms:

Umschaltwalze = reversing cylinder. — Kontakt am Führerbremsventil... = driver's brake valve notch in high-speed application position. — Geschlossen = shut. — Kleinautomat = automatic circuit breaker. — Zellen = cells. — Motorsteuer strom = motor control current. — Vom Hauptluftbehälter = from compressed-air main reservoir. — Arbeitsstrom = feed current. — Steuerstrom = control current. — Rückleitung = return wire. — Hauptluftleitung = compressed-air train pipe. — Zum Steuerventil der Druckluftbremse = to triple valve of compressed air brake. — End (Lauf-) Drehgestell = outer (carrying) bogie. — Mittel (Trieb-) Drehgestell = middle (motor) bogie.

which is operated from the coach in emergency. When the pressure in the train pipe is reduced and this switch shuts, the current to the motor is cut off and the magnetic rail brake fully applied.

The last mentioned circuit passes by the reversing cylinders for forward and backward running, so that the release of the magnetic rail brake only occurs in the running position. When the reversing cylinder is in the neutral position, air from the main brake pipe can be released without the magnetic brake being applied, so that, for example, work can be done on the vehicle, say in the shed, without the rail brake being applied and perhaps injuring someone.

The electro-magnetic brake will be used in the near future not only on the high-speed railcars (over 130 km. = 80.8 miles an hour), but also on those for heavily graded lines (up to 1 in 10), on which the highest brake efficiency is required. The electro-magnetic rail brake is designed to come into action immediately if one of the other brakes (compressed-air shoe brake and geared hydraulic brake) fails to operate or operates with insufficient power, or if the speed limit say of 20 km. (12.4 miles) an hour is exceeded.

The electro-magnetic rail brake, in this case, has to be powerful enough by itself to stop the vehicle within a given distance.

[656. 222.5 (.73)]

Note on the high-speed trains
between Chicago, St. Paul and Minneapolis,

by Léon PONDEVEAUX.

A very interesting feature to be noted in the United States 1935 train services which, taken as a whole, show substantial improvements, is the introduction of three high-speed competitive trains between Chicago and the two great twin cities of the State of Minnesota : St. Paul and Minneapolis.

The reason for their introduction, their technical features, and their operating results for the first few months have been reported in detail by Messrs. Coverdale and Colpitts, Consulting Engineers, New York; the main points of their report are given below with additional information on certain points.

I. — Reason for the introduction of the high-speed trains.

The railway crisis in the U. S. A. began in 1921. Relatively to 1920 the passenger traffic receipts had fallen 33 % in 1929, and 60 % in 1935. The drop was greater in the area north west of Chicago than anywhere else, and was accompanied by an enormous increase in the traffic by other methods of transport, such as road motor and air services. At the present time the road passenger traffic is more than 20 times the railway passenger traffic. Consequently if one twentieth of the road traffic could be recovered, the railway traffic would be doubled. The problem to be solved was a new one. The average weight of road vehicles is steadily decreasing and the improvements in the vehicles and in the roads have considerably reduced the operating costs. The tendency on the railways, on the contrary, has been to make the passenger vehicles heavier and more costly, without any compensating advantages. But on the railways also, technical progress of the last years had made possible a reduction in the weight of the power units together with the attainment of high speeds, and the application of road motor and aircraft design to railway rolling stock. High speed, comfort and lower fares resulting from lower operating costs ought to attract the public and result in the situation being reversed to the benefit of the railway.

Wat was the position in this area ? The four States from which the traffic can be drawn between Chicago and Minneapolis are Illinois, Wisconsin, Iowa and Minnesota with some 16 million inhabitants, including 3 376 000 in Chicago, 464 000 in Minneapolis and 272 000 in St. Paul. In addition to two smaller Companies, the Minneapolis St. Paul and Sault-Ste Marie Railway and the Chicago Great Western Railroad, the railway services between Chicago and Minneapolis are given by the Burlington Lines, the Chicago, Milwaukee, St. Paul and Pacific Railroad and the Chicago and North Western Railway. We will deal with each of the three great railways in turn.

II. — Working conditions and timetables.

1. *Burlington Zephyr.*

The Burlington line is 709.5 km. (441 miles) long and serves a number of large cities (Aurora, 46 589 inhabitants; Dubuque, 41 679; La Crosse, 39 614; Winona, 20 850). Three quarters of the line are double-tracked; the gradients are 1 in 333 to 1 in 63, and there are many sharp curves (23 % of the length). The rails weigh as a rule 50 kgr. (100 lb. per yard), the sleepers are creosoted, and the ballast is gravel. There are 12 railway level crossings and 267 road level crossings, 186 of which are not protected. Permanent way work which had to be done before the high-speed services could be introduced cost 230 000 dollars. The fastest train previously took 10 1/2 hours for the journey, the average speed being 67.6 km. (42 miles) an hour.

The Company introduced on this service the streamlined trains known as the « Zephyrs », based on the first « Zephyr » run for the first time on the Lincoln-Kansas City line, on the 11th November 1934, when it covered the 1 633 km. (1 015 miles) between Chicago and Denver in 13 h. 5 m., at an average speed of 125.6 km. (78 miles) an hour. This train was built by Messrs. Edward G. Budd & Co. and consists of a triplet articulated set carried on four 4-wheeled bogies. The body frames are built of rustless steel and the outside plating is streamlined longitudinally. It is driven by a Winton 2-stroke 660-H.P. diesel engine direct coupled to a 750-volt electric generator. Two traction motors, each of 300-H.P. are fitted on the leading bogie, the axles of which they drive.

The leading body is 22 m. (72′ 2″) long and contains the power unit and a luggage and parcels compartment. It weighs 54 tons. The second body (17.50 m. = 57′ 5″) long weigh 24.4 tons, consist of a compartment with seats for 40 passengers, a kitchen, a pantry, a bar, and a buffet with seats for 16 passengers. The third body, 19.5 m. (64′) long, weighing 23.6 tons, is made up of a compartment with 24 seats, and a saloon with 22 armchairs. The unit, therefore, is 59 m. (193′ 7″) long with seats for 86 passengers and weighs 102 tons. The centre of gravity is 1.25 to 1.40 m. (4′ 1 13/64″ to 4′ 7 1/8″) above rail level. The unit is air-conditioned and wireless is fitted in the compartments. No vibration has been noticed in the compartments.

The first service was started on the 21st April, 1935, and the second on the 2nd June 1935. The present train service is shown on the timetable hereafter, the average speeds being given in brackets :

icago.	Dep. 8.0 a.m.	4.0 p.m.	Arr. 3.0 p.m.	10.59 p.m.
	(65.1 miles)	(65.1 miles)	(58.4 miles)	(58.4 miles)
rora . . . . . (38 miles)	Dep. 8.35 a.m.	4.35 p.m.	Dep. 2.21 p.m.	10.20 p.m.
	(66.1 miles)		(63.6 miles)	
vanna . . . . (145 miles)	Arr. 10.12 a.m. Dep. 10.13 a.m.		Dep. 12.40 p.m. Arr. 12.39 p.m.	
	(68.5 miles)	(66.3 miles)	(59.9 miles)	(62.5 miles)
buque . . . . (185 miles)	Dep. 10.48 a.m.	6.48 p.m.	Dep. 11.59 a.m.	7.59 p.m.
	(77.1 miles)		(71.0 miles)	(73.6 miles)

Prairie du Chien . (239 miles)	Dep. 11.30 a.m. (66.4 miles)		Dep. 11.15 a.m. (71.5 miles)	(72.45 miles)
North La Crosse . (301 miles)	Dep. 12.26 p.m. (68.1 miles)	8.26 p.m. (68.1 miles)	Dep. 10.23 a.m. (62.2 miles)	6.23 p.m. (62.2 miles)
Miner (Winona) . (326 miles)	Dep. 12.48 p.m. (61.8 miles)	8.48 p.m. (62.3 miles)	Dep. 9.59 a.m. (70.5 miles)	5.59 p.m. (70.5 miles)
St. Paul. . . . . (431 miles)	Arr. 2.30 p.m. (20.0 miles)	10.29 p.m. (20.0 miles)	Dep. 8.30 a.m. (20.0 miles)	4.30 p.m. (20.0 miles)
Minneapolis . . . (441 miles)	Arr. 3.0 p.m.	10.59 p.m.	Dep. 8.0 a.m.	4.0 p.m.

The whole journey lasts 7 hours (average speed 101.3 km. = 63 miles) an hour, a reduction of 3 1/2 hours on the old timing. If we only consider the run as far as St. Paul, so as to cut out the serious speed reduction between St. Paul and Minneapolis, the average speed is 106.6 km. (66.2 miles) an hour. The speed frequently reaches 150 km. (93.2 miles), the maximum speed being 175 km. (108.7 miles) an hour.

2. *The Hiawatha.*

The Chicago, Milwaukee, St. Paul Pacific Railroad is 667.1 km. (420.7 miles) long. It serves the large city of Minneapolis, with 578 249 inhabitants, and runs through La Crosse and Winona, like the Burlington line. Except for some 16 km. (10 miles), the line is double-tracked The gradients vary from 1 in 333 to 1 in 80, and 20 % of the line is on sharp curves. The rails are generally 50 kgr. (100 lb. per yard); the sleepers are creosoted, and the ballast is gravel. There are 26 railway level crossings, and 441 road crossings, 255 of which are not protected. The cost of putting the track into good order for the high-speed trains, the signals and interlockings, was about 154 000 dollars.

The fastest train previously took 8 1/2 hours for the run (average speed of 79.6 km. = 49.5 miles) an hour.

The Company introduced on this service a 7-coach train called the « Hiawatha », hauled by an oil-fired steam Atlantic type locomotive built by the American Locomotive Company. The adhesive weight is 64.6 tons, the weight in working order being : locomotive 129 tons, tender 120 tons, total 249 tons. The boiler pressure is 21 kgr./cm^2 (300 lb. per sq. in.), and the cylinders are 480 mm. (16′ 7/8″) diameter, 710 mm. (28″) stroke. The driving wheel diameter is 2.13 m. (7′). The tractive effort is 13.8 tons and the normal H.P. 3 000. All journals are fitted with roller bearings. The total length is 26.60 m. (87′ 4″), and the centre of gravity is 1.97 m. (6′ 5 9/16″) above rail level.

The locomotive, which is remarkably steady at 160 km. (100 miles) an hour, is streamlined, the boiler casing having the same section as the carriages. The carriages were designed and built by the railway company in its own workshops, in 1934. They are tubular in form and are entirely free from exterior projections. The bodies are built of rolled sections, flats and sheets in carbon steel assembled by arc welding or spot welding. The sections of the body are strongly welded to the frame, the centre frame girder also being welded to the floor. In this way, any shock is distributed through the whole body. The carriages are carried on four-wheeled bogies, with roller-bearing axle boxes. The centre of gravity is 1.54 m. (5′ 5/8″) above rail level.

The inside width is greater than that of the ordinary stock. The saloon cars are fitted with particularly comfortable revolving seats. Each carriage has smoking compartments for women and for men. The whole train is air-conditioned. The carriages ride very well, no shock being felt on taking curves, except in the leading vehicle in which some vibration is felt from the engine.

No luggage, parcels, or post compartment is provided. The train usually consists of a restaurant-bar car (23.20 m. = 76 ft. 1 in. long, weight 59 tons; 48 seats); four ordinary coaches (24.80 m. = 81′ 4″ long; 51 tons; 63 seats); leading saloon car (24.80 m. long, 52 tons; 37 seats), and trailing saloon car (24.80 m. long, 50 tons; 39 seats), or a total of 172 m. (564′), 365 tons, 376 seats. The vehicles are 30 % lighter than the ordinary stock, the reduction in weight per seat being 20 %. Including the locomotive, the weight of the train, 615 tons, is much less than the 827-ton weight of the ordinary expresses running over the line, although the number of seats is only slightly less (376 against 421).

The train can take 3, 4 or 5 ordinary vehicles in addition. The service was started on the 29th May 1935 to the following timetable :

Chicago	Dep.	1.0 p.m.		Arr.	7.30 p.m.	
			(68.0 miles)			(68.0 miles)
Milwaukee (85.0 miles)	Arr. Dep.	2.15 p.m. 2.17 p.m.		Dep. Arr.	6.15 p.m. 6.10 p.m.	
			(66.3 miles)			(66.3 miles)
Portage (178.0 miles)	Arr. Dep.	3.41 p.m. 3.42 p.m.		Dep. Arr.	4.46 p.m. 4.45 p.m.	
			(71.8 miles)			(73.8 miles)
New-Lisbon (220.7 miles)	Dep.	4.18 p.m.		Dep.	4.10 p.m.	
			(70.3 miles)			(70.3 miles)
La Crosse (280.7 miles)	Arr. Dep.	5.9 p.m. 5.14 p.m.		Dep. Arr.	3.19 p.m. 3.14 p.m.	
			(52.1 miles)			(53.8 miles)
Winona (307.7 miles)	Dep.	5.45 p.m.		Dep.	2.44 p.m.	
			(63.7 miles)			(62.4 miles)
Red Wing (370.0 miles)	Dep.	6.43 p.m.		Dep.	1.44 p.m.	
			(51.1 miles)			(54.6 miles)
St. Paul (410.0 miles)	Arr.	7.30 p.m.		Dep.	1.0 p.m.	
			(21.4 miles)			(21.4 miles)
Minneapolis (420.7 miles)	Arr.	8.0 p.m.		Dep.	12.30 p.m.	

The total journey time, 7 hours, is the same as for the « Zephyr », although the distance is shorter. The average overall speed is 96.7 km. (60.1 miles) per hour, but to St. Paul it is 101.5 km. (63.1 miles) an hour. The time spent is 1 1/2 hours less than with the old timing.

3. *The « 400 ».*

The line of the Chicago & North Western Railroad is the shortest of the three (674.5 km. = 419.1 miles). It serves Eau Claire (26 287 inhabitants) in addition to Milwaukee. Three quarters of the line are double-tracked; the gradients vary from 1 in 333 to 1 in 63, and the curves, whilst smaller in radius than on the other lines, amount to only 12 % of the total length of line. 50-kgr. (100 lb. per yard) rails are generally used. Broken stone ballast is used between Chicago and Milwaukee, and gravel on to Minneapolis. There are 7 level crossings with railways and 384 roads crossings, 218 of which are not guarded. The cost of putting the line in order for the high-speed trains was 145 000 dollars.

Previously to the introduction of this train, the journey took 8 hours 35 minutes, the average speed being 78.5 km. (48.8 miles) an hour.

The Company put into service on this run a train of 6 ordinary coaches hauled by an oil-fired steam locomotive rebuilt for high-speed work. The *Pacific* type engine was built, in 1923, by the American Locomotive Company. The adhesive weight is 80 tons ; the weight in working order is 134 tons; the tender weighs 135 tons, so that the total weight of engine and tender is 269 tons. The boiler pressure is 16 kgr. (228 lb. per sq. in.); the cylinders are 660 mm. (26″) diameter and the piston stroke is 710 mm. (28″). The driving wheels are 2 m. (6′ 6 3/4″) in diameter. The tractive effort is 20.5 tons, the normal horse-power 3 025, the length 27 m. (88′ 7″) and the centre of gravity 1.97 m. (6′ 5 9/16″) above rail level.

The steel carriages are of standard design, and carried on six-wheeled cast steel bogies. They are steam-heated and air-conditioned and have been specially fitted out. Their centre of gravity is 1.52 m. (4′ 11 13/16″) above rail level.

The train usually consists of one carriage with a luggage compartment, a centre section, and a smoking compartment (23.30 m. = 76 ft. 5 3/8 in. long, 69.5 tons, 62 seats); one saloon car with a smoking compartment (24 m. = 78 ft. 9 in. long; 69 tons; 40 seats); a restaurant car (25 m. = 82 ft. long, 80 tons; 36 seats); one ordinary carriage (24.80 m. = 81′ 4 3/8″ long, 69.5 tons, 50 seats); a North Western saloon car (24 m. = 78′ 9″ long; 64 tons, 50 seats), and a Pulmann saloon car (25.60 m. = 84′ long, 78.5 tons, 36 seats), making a total of 147.30 m. 481′ 3 3/4″, 430.5 tons, and 268 seats. Including the engine, the length is 175 m. (569′ 10 3/4″) and the weight 700 tons.

This high-speed train known as the « 400 » was put into service on the 2nd January 1935, and runs to the following timetable :

Chicago	Dep. 3.30 p.m.		Arr. 10.0 p.m.	
		(68.0 miles)		(68.0 miles)
Milwaukee. . . . (85.0 miles)	Dep. 4.45 p.m.		Dep. 8.45 p.m.	
		(59.0 miles)		(60.0 miles)
South Beaver Dam. (148.0 miles)	Dep. 5.49 p.m.		Dep. 7.42 p.m.	
		(65.9 miles)		(64.7 miles)
Adams . . . . . (209.2 miles)	Dep. 6.45 p.m.		Dep. 6.45 p.m.	
		(63.7 miles)		(62.6 miles)
Eau Claire . . . (323.1 miles)	Dep. 8.32 p.m.		Dep. 4.57 p.m.	
		(58.3 miles)		(59.0 miles)
St. Paul . . . . (408.6 miles)	Arr. 10.0 p.m.		Dep. 3.30 p.m.	
		(21.0 miles)		(21.0 miles)
Minneapolis . . . (419.1 miles)	Arr. 10.30 p.m.		Dep. 3.0 p.m.	

The total journey time is 7 hours as for the other two high-speed trains, although the distance is the shortest. The average speed is 96.3 km. (59.8 miles) for the whole run and 101.2 km. (62.9 miles) to St. Paul. The reduction on the old timing is 1 h. 35 m.

III. — Operating results.

Having given the principal characteristics of these three competitive high-speed trains, we will now give particulars of the first operating results obtained. This will enable us not only to compare them, but also to derive from these experiments information on modern railway operation.

If the « 400 » on the North Western has not enabled any other trains to be cancelled, the Burlington « Zephyrs » and the « Hiawatha » have enabled the other two Companies to cancel certain trains or railcar services. The rates are the same by the three trains, and are 18 centimes (1) per kilometre in the ordinary coaches, 27 centimes first class, and 29 centimes in the Pullman. These rates are in force throughout the West and were reduced on the 1st December 1933. The through journey cost 123 francs for the ordinary fare, 184 francs 1st class, and 199 Pullman. The return journey costs 221.40 francs, 257.60 francs, and 287.60 francs respectively. The rates in France for the same average distance of 680 km. (422.5 miles) are : 2nd class 207 francs, 1st class 306 francs for the single journey, and 2nd class 331 francs, 1st class 459 francs for the return journey, the Pullman supplement being comparatively high.

Although the three trains cover much the same distance, the country through which they run differs considerably. The « Hiawatha » and « 400 » parallel one another between Chicago and Milwaukee and serve much the same territory for 250 km. (165 miles) west of Milwaukee. The « Hiawatha » and « Zephyr » follow parallel lines between La Crosse and Minneapolis for a distance of 220 km. (137 miles). The « Hiawatha » has the advantage over the other two in that the intermediate towns are larger. The through traffic by the « Zephyr » is 80 % of the total, whereas by the other two trains it is only 50 %. As the slightest reduction in time can displace the traffic, competition is extremely severe.

These trains have been a great success and especially in the case of the « Zephyr », passengers have had to be refused on certain days. The views of the passengers have been ascertained by means of questionnaires. The replies show that if the « Zephyr » had not run 11 % of the passengers would have used motor cars, 5 % motor charabancs, 8 % aeroplanes and only 76 % other trains. In the case of the « Hiawatha » 20 % would have used motor cars, 7 % motor charabancs, 5 % aeroplanes, and 68 % other trains. The number of passengers has been as high as 100 in the Zephyr (86 seats), 358 in the « Hiawatha » (376 seats) and 289 in the « 400 » (268 seats).

It is very difficult to say what proportion of this traffic has been taken from other trains and from road and air services. For some months, the « 400 », the first to be introduced, took passengers from other lines, as well as from the highway. Its receipts have fallen, however, since the « Zephyrs » were put into service. Later on the « Hiawatha » took its passengers partly from its own system and partly from the other two.

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(1) All calculations in francs and centimes are in French currency.

The traffic recovered by the three fast services from road and air services may be taken as 35 %. The public have shown great liking for these fast comfortable trains, and this method of transport, with its lower rates, may be expected to be used in other parts of the United States. As these trains are well patronised their working costs will be reduced and it will become possible to reduce the rates. This should attract still more passengers.

The statistics compiled by the three railways show that the double service each day of the Burlington Zephyrs in June and July 1935 showed receipts of 123 590 dollars, including 9 875 dining-car receipts. The expenditure amounted to 47 395 dollars made up of : wages 16 640, fuel and oil 2 413, maintenance 3 562, diesel engine repairs 6 197, dining car expenses 15 861. This leaves a net receipt of 76 195 dollars, or about 1 150 000 francs.

The receipts from the « Hiawatha » amounted to 188 610 dollars, including 17 263 from the dining car. The expenditure was 61 314 dollars, made up of : wages 14 108, fuel 5 488, locomotive repairs 7 860, carriage repairs 9 212, dining-car costs 14 884. The net receipts thus amounted to 127 296 dollars or some 1 900 000 francs.

The « 400 » receipts amounted to 92 045 dollars, including 8 612 from the restaurant car. The expenditure in dollars was : wages 13 123, fuel 6 552, locomotive repairs 9 321, carriage repairs 5 937. The net receipts were therefore only 33 198 dollars, or less than 500 000 francs.

The « Zephyrs » have carried 17 173 passengers and consumed 128 000 litres (28 160 Br. gall.) of fuel; the « Hiawatha » 35 376 passengers and 1 026 000 litres (225 720 Br. gall.); and the « 400 » 15 617 passengers and 1 493 000 litres (328 460 Br. gall.).

The « Hiawatha » and « 400 » are both steam trains made up of ordinary non-articulated stock and to some extent follow the same layout. The figures quite clearly show that the former proves more attractive to the passengers on account of its greater comfort and novelty. The intermediate population is denser in the country it runs through and it can carry 40 % more passengers than the « 400 ». It seems natural that its profit is appreciably greater. The line is flatter, the locomotives use less oil, and the total weight is lower.

The « Hiawatha » therefore should be selected if any useful comparison is to be made with the « Zephyr ». The operating conditions of the two trains are entirely different. The small capacity of the « Zephyr » is a disadvantage, as even when two services are run each day the total carrying capacity is less than that of the « Hiawatha ». This has been overcome in the case of the « Zephyr « on the Lincoln-Kansas City service by attaching a trailer but in the case under consideration with the Zephyr almost always running fully loaded this would not be sufficient. The Company are considering the question of replacing the existing trains by others of much greater capacity.

To make an exact comparison the « Zephyrs » must be assumed as working with an additional vehicle and with the parcels compartment of the first vehicle used to carry passengers. Each « Zephyr » would then consist of a motor coach weighing 53.9 tons and providing 28 seats, a restaurant car weighing 24.8

tons with seats for 56, and a saloon car weighing 23.5 tons and seating 46, or a total of 127 tons and 170 seats, or 340 for the two « Zephyrs », a total capacity much the same as that of the « Hiawatha » (365 seats).

If the coefficient of user be taken as the same i.e. very close to the maximum as the train runs almost always full, the double daily « Zephyr » service can earn 220 800 dollars including 18 300 from the restaurants in two months, comparable with the previous months of June and and July. The expenditure over the same period would amount to 57 900 dollars made up of : wages 16 700, fuel and lubrication 2 800, repairs to stock 4 800, maintenance of diesel engines 6 500, restaurant-car expenses 23 600. The net receipt of 162 900 dollars should still be reduced by 4 300 dollars for rolling stock amortization, 5 300 for interest on invested capital, 1 100 for taxes. The net revenue would thus be 152 200 dollars.

On the other hand, the net receipts of the « Hiawatha » given above i.e. 127 296 dollars should be reduced by 5 102 dollars for rolling stock amortization, 6 378 for interest on capital, and 1 275 for taxes, leaving a net return of 114 541 dollars.

The cost of carrying the assumed traffic in the enlarged « Zephyrs » is based on the actual operating costs for 3-coach trains, and on the differences found between 3 and 4-coach trains on the « Zephyrs » in service between Lincoln and Kansas City.

As regards amortization, the ordinary depreciation rate of 4 % can be used in the case of the « Hiawatha ». A smaller rate should be taken for the « Zephyrs » seeing that the vehicles are lighter and built of rustless steel. This new type of stock probably will not get out of date so quickly Experience seems to show that the details of the diesel engine are not likely to wear out any more rapidly than steam locomotive parts. The same rate of 4 % has nonetheless been applied to the two trains.

The interest on capital has been calculated at 4 % per annum on the cost of the rolling stock. The taxes are taken at 1 % of the invested capital.

As regards capital investment, the « Zephyrs » are new designs, built on new methods, and the price will fall as these trains increase in number and are mass produced. Similarly, though to a smaller degree, the cost of the « Hiawatha » was greater than that of the ordinary stock and here again the price will fall as more such trains are built. The lowest estimate has been used in the calculations.

The comparison shows that the new revenue from the enlarged « Zephyrs » will exceed that of the « Hiawatha » by some 3 800 dollars or by 33 %. The seats available in the « Zephyrs » in two months equal 340 × 61 days, or 20 740. The net revenue per seat available is $\frac{152\,200}{20\,740}$ 7.34 dollars, or 110 French francs.

The seats available on the « Hiawatha » in the same period were 365 × 61 or 22 265. The net revenue per seat was $\frac{114\,541}{22\,265} \Big\}$ 5.14 dollars, or 77 French francs. The « Zephyr » in this respect is 50 % better.

This result is most important and most encouraging for the future extension of streamlined diesel trains. It fully justifies the large-scale and conclusive experiment made by the Burlington Lines, which will have considerable repercussions in the United States and Europe, and will also encourage such trials elsewhere and these will favour the development of the machines. Besides this, the results obtained with the « Hiawatha » and « 400 » light steam trains should be borne in mind by railway engineers. From every aspect, the three high-speed services started in 1935 between Chicago and Minneapolis have contributed to the progress of railway traction.

[625. 212 (.44)]

Measures taken by the French Railways to improve the quality of the tyres,

by M. ARTIGNAN,

Engineer (Tests, inspection and acceptance), « Nord » Railway, France.

(*Revue Générale des Chemins de fer.*)

The tyres used under French rolling stock during the ten years subsequent to the war were made and inspected to specification No. 14 of March 1918.

This specification provided for two classes of tyres : G and H having the tensile strengths given later on. The steel had to be either Martin, electric, or crucible. The defective metal in the top or bottom of the ingot and all traces of piping had to be removed either by punching out the middle after flattening the ingot into a cheese (fig. 1, *a, b, c*) or by some alternate method.

The ingots had to be formed into cheeses under a hammer or a press, and these cheeses after having any defects removed, were to be rolled to the desired diameter and section.

The heat treatment of the tyres was left to the discretion of the manufacturer, but in all cases the tyre had to be finally either air hardened or tempered. When the tyres were not given any special heat treatment, annealing followed by air hardening was obligatory.

The tests specified for the two classes of tyre were a drop test, and a tensile test from one tyre per cast.

The tyre selected for the drop test had to stand, without breaking or cracking, a blow from a 1 000-kgr. (2 200 lb.) tup falling 10 m. (32.8 ft.). This height is that adopted for tyres 65 mm. (2 9/16 in.) thick in the tread; the height was increased or reduced 0.07 m. (2 3/4 in.) for each millimetre (3/64 in.) thicker or thinner.

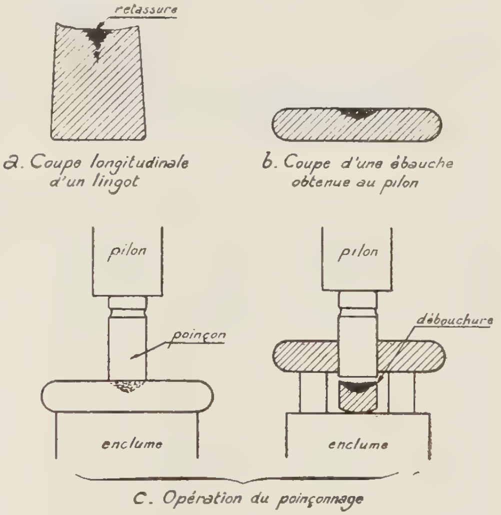

retassure
a. Coupe longitudinale d'un lingot
b. Coupe d'une ébauche obtenue au pilon
pilon
poinçon
enclume
pilon
débouchure
enclume
C. Opération du poinçonnage

Fig. 1.

Explanation of French terms:

a) Coupe longitudinale... = longitudinal section through an ingot. — Retassure = piping. — *b*) Coupe d'une ébauche... = section through a cheese formed under a power hammer. — *c*) Opération du poinçonnage. = method of punching. — Pilon = hammer. — Poinçon = punch. — Enclume = anvil. — Débouchure = Punched-out metal.

The tensile test specified was :

CLASS OF TYRE.	TENSILE TEST ON COLD TEST PIECE.	
	Minimum tensile strength per mm² (per sq. in.) of the original section S.	Minimum elongation, %, measured on a length $\overline{66.67\ S}$.
G	70 kgr. (44.4 Engl. tons).	14
H	90 kgr. (57.2 Engl. tons).	8

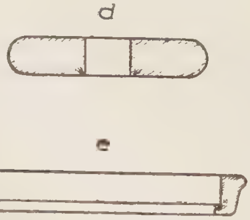
Tyres made and inspected to this specification gave good results up to the end of 1928, when as a result of certain failures, the specification was revised several times. We will consider these revisions after having looked into the causes of the defects reported.

I. — **Causes of tyre failures.**

Most tyre failures are due to defects in the tyres such as piping or contraction cracks. In rare cases they were attributed to defective annealing or to quite fortuitous causes, such as irregularity in pouring the ingot or the presence of a piece of foreign metal in the tyre.

We do not propose to deal in this article with the defect known as « exfoliation » as, so far as we are aware, it has never caused a breakage.

a) *Piping.* — This defect, the cause of most of the failures reported, is mostly met with in tyres made from individual ingots. If the punching during forging does not remove most of the piping and segregated metal (fig. 2, *d, e*) the tyres are nearly always defective, sometimes seriously, at the lip (fig. 3, *f, g*). The defects are easily shown by taking macrographs.



Any traces of piping left in the cheese **d** *will be found in the tyre at* **e**.

Fig. 2.

The fractures due to piping can be transverse (fig. 4, *h, i,* which relate to the same tyre) or longitudinal (fig. 4, *j*).

b) *Contraction cracks.* — There are two sorts : those occurring during reheating, and those during hardening.

Fractures due to cracks set up during reheating start from a incipient crack like that shown in the macrograph, figure 5, *k*.

This crack differs from piping by occurring as a rule in the heart of the tyre, in a zone which may be free from segregation.

The hardening cracks found in H-steel tyres, when extensive, look like those in the photograph figure 5, *l*. They run transversely and their colour is bluish. They cause the tyre to break, sometimes even while it is being turned.

c) *Defective annealing.* — Micrographs of tyres broken without apparent cause have shown that the failure is due to inadequate or no annealing. The only non-annealed tyre we have examined was of foreign origin.

d) *Irregularly poured ingot.* — One tyre (of foreign manufacture) was de-

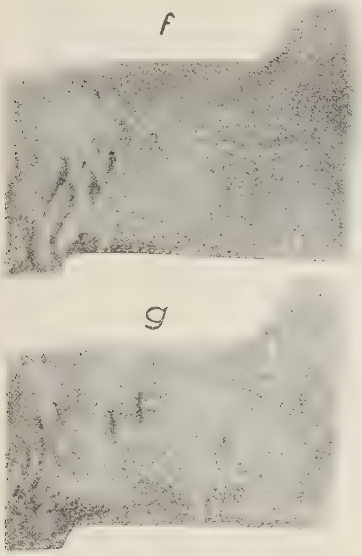


Fig. 3.

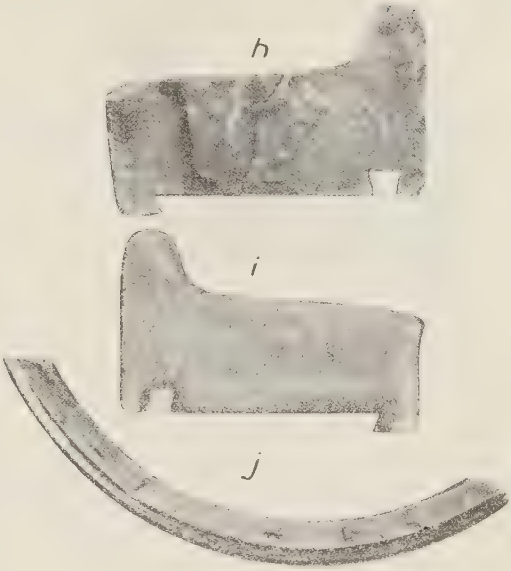


Fig. 4.

fective through the metal having scaffolded in the ingot mould during pouring (fig. 6).

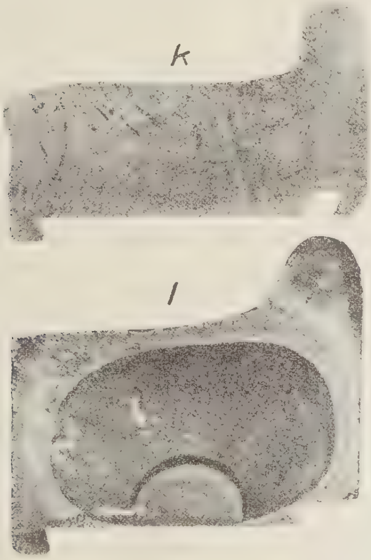


Fig. 5.

e) *Inclusion of foreign metal.* The macrograph (fig. 7) shows that in the tyre under examination a piece of mild steel was included. This was part of the protection plate in the bottom of the mould which had turned op during pouring.

II. — Clauses introduced in the specification in order to prevent as far as possible the above defects.

The investigations into the causes of failures occurring before 1929 having shown that most of them were due to tyres showing considerable traces of piping, two additional classes of tyre, GG and HH, were introduced for use on certain stock requiring tyres of high quality.

GG and HH tyres showing the same hardness as G and H tyres were to be obtained from cropped ingots cut into slices; the suppliers were still at liberty to manufacture G and H tyres from individual ingots.

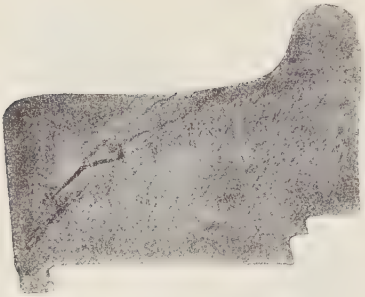


Fig. 6.

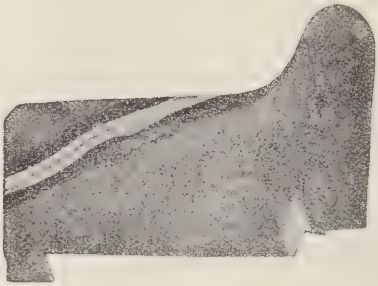


Fig. 7.

When slicing the ingots, the top discard was to be at least 15 %, and each ingot must give at least three slices (fig. 8). The new specification specified furthermore that the hole punched through the slice was to be at least 200 mm. (7 7/8 in.) in diameter, whereas the old specification did not state the size.

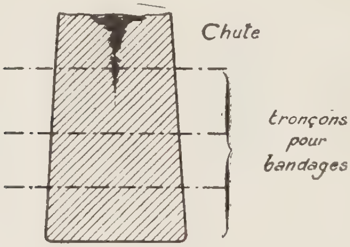


Fig. 8. — Ingot for three tyres.

Note : Chute = discard. — Tronçons pour bandages = slices for tyres.

Instead of « annealing », the new specification required « heat treatment » and specified the use of recording pyrometers for ensuring the different heat treatment operations being the same when one cast was treated in a number of batches.

The railways, moreover, having found that the drop test on one tyre per cast, however large the cast might be, was perhaps insufficient, now required one drop test per batch of 50 or fraction of 50 tyres with a minimum of one per cast. They also required 3 tensile tests for each tyre drop-tested, instead of one, and selected these from :

1. near the tread (1 test piece);

2. parts of the tyre likely to contain traces of piping (2 test pieces near the bore, one on the flange side and the other the lip side).

The maximum admissible phosphorus content was also reduced from 0.07 to 0.06 %.

The object of this first revision was to :

1. reduce the number of tyres likely to be piped, by introducing classes GG and HH tyres, and by increasing the number of drop and tensile tests;

2. control the heat treatment by using recording pyrometers;

3. reduce the admissible phosphorus content.

Two alterations, which did not improve the quality, were introduced in November 1929 and February 1930 at the request of the makers. Their object was :

1. to enable some steelworks equipped to manufacture GG and HH class tyres, to supply these classes instead of classes G and H which were on order :

2. to reduce the diameter of the punched hole to 150 mm. (6 in.) in the case of tyres weighing less than 200 kgr. (440 lb.);

3. to reduce the height of drop of the 1 000-kgr. (2 200 lb.) tup from 10 to 9 m. (32.8 to 29.5 ft.) in the case of tyres of 800 to 700 mm. (2 ft. 7 1/2 in. to 2 ft. 3 1/2 in.) inside diameter, and to 8 m. (26.25 ft.) when the inside diameter was less than 700 mm. (2 ft. 3 1/2 in.).

August 1932 revision. — In spite of the new requirements introduced from 1929 to 1932 in the tyre specifications, it was considered desirable, in the interests of safety, to make the specifications still more severe. In particular, the precautions to be taken by the makers each time the tyres are heated, in order to avoid shrinkage cracks and to ensure the heat of the tyre being throughout at the proper temperature, were laid down in detail.

The specification adopted prescribed also the use of standard recording pyrometers and required the pyrometers to be so located in the furnaces that the temperature of the piles of tyres themselves could be exactly known.

The following additional tests on the tyres drop-tested had to be made for information :

1. Shock bend test on notched bars (resilience);

2. Micrographical examination;

3. Macrographical examination.

The method of selecting and preparing the test pieces and the way the tests are to be carried out are also specified.

Up to the 1st July 1934, the following conclusions have been come to as the result of tests on 655 tyres from makers in the North and East of France :

Resilience. — *a*) The value used was the lowest of the three obtained from each tyre.

b) The minimum values of the different classes lie between 0.5 and 4.8 (10 abnormal results being ignored) and no distinction could be drawn between the classes.

c) When the results obtained with tyres from certain makers were examined, it was found that the mere fact of having prescribed these tests was the beginning of a definite improvement in the quality.

d) As will be seen in the next paragraph, most of the low resilience values were ascribed either to rolling at too high temperature or to inadequate or insufficient annealing or to the presence of non-metallic inclusions.

e) From these tests the conclusion could be drawn that in the present state of French metallurgical practice a minimum resilience value of 2 could be laid down.

Macrographical examinations. — *a*) Certain classes G and H tyres showed traces of piping which might have started longitudinal cracks and possibly fractures. The macrographs (fig. 3, *f*, *g*) are typical in this respect : the section from which the macrograph (fig. 3, *f*) was taken had undergone a bend test and broke at the place where the piping existed as shown in the photographs (fig. 9, *m*, *n*).

After all, the method of making classes G and H tyres does not ensure all piping being removed. The macrographical examination of one tyre from a batch is no guarantee as regards the remainder.

There appeared, therefore, to be no reason to retain the macrographical tests for the classes G and H tyres.

b) Tyres of GG and HH classes. — The macrographs of GG and HH tyres are definitely better as regards freedom from piping than those from the other classes.

Figure 10 shows such a defect, however, in a class GG tyre. The results were so constant that it was felt possible to require macrographs from the GG and

HH tyres and reject any found defective thereby.

Micrographical tests. — Figure 11 consists of a number of micrographs from tyres of various resiliences (*o*, *p*, *q*, *r*, *s* and *t*) from steels of low resilience not properly annealed.

Micrographs *u* and *v* show properly annealed steels of good resilience.

Micrographs *w* and *x* show extensive non-metallic inclusions.

Micrographs *y* and *z* are from tyres rolled too hot.

Whilst these tests are most interesting, they are too difficult to apply for acceptance purposes, and so have not been included in the specifications.

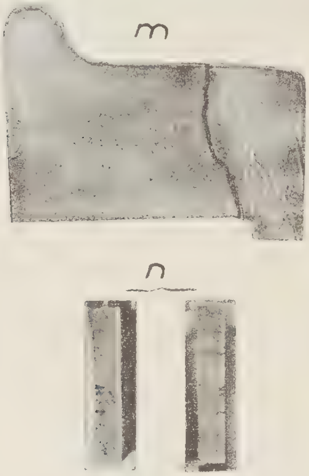


Fig. 9.

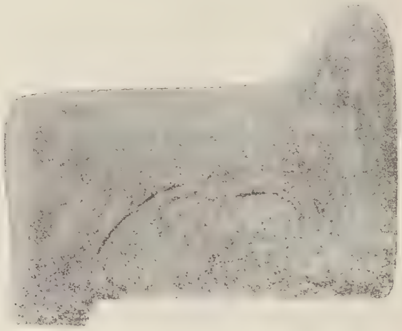


Fig. 10.

III. — Preparation of the new specification.

After discussion with the makers, the Railways adopted, in July 1935, a new specification which differed from the former one in the following points :

1. *Manufacture.* — *a*) G, H, GG and HH tyres can be made from slices from cropped blooms. The discard must be sufficient to remove all traces of piping and segregation, this condition being checked by a macrographical test from the ends of each bloom.

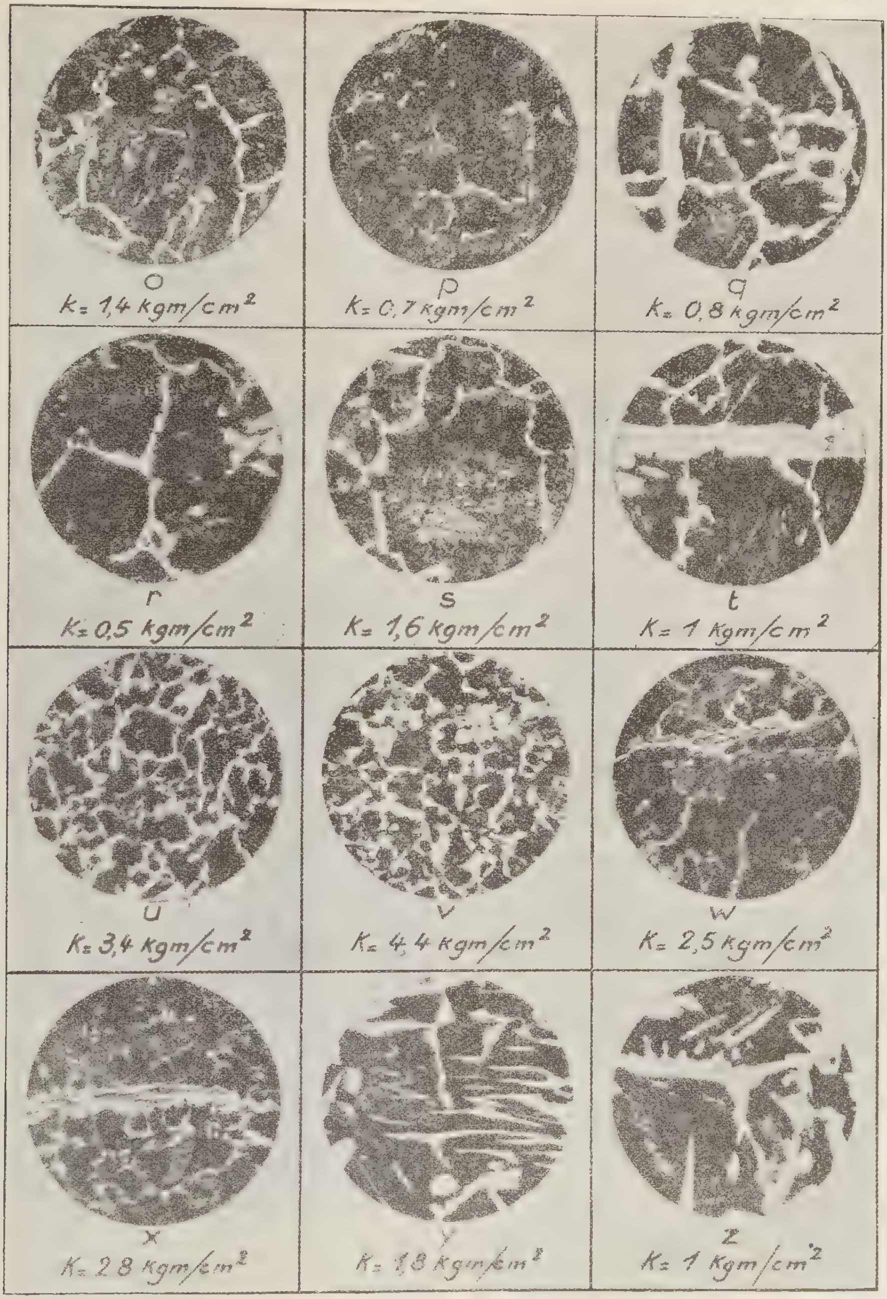
b) The heat treatment is left to the maker, but must not include hardening in a liquid.

2. *Tests on tyres selected from the batches offered.* — *a*) Shock bend tests on notched bars are specified for classes G, H, GG and HH tyres. The resilience from each of three bars from the tyres tested shall be greater than or at least equal to 2.

b) A macrographical test is required in classes GG and HH tyres and must show the tyre tested to be free from piping and segregation.

c) The phosphorus content in all four classes of tyre must not exceed 0.04 % (instead of 0.06 % in the previous specification).

3. *Tests carried out on all tyres offered.* — All tyres of the four classes must undergo the Brinell hardness test so as to reject any the hardness number of which is outside the specified limits.



o $K = 1{,}4$ kgm/cm^2

p $K = 0{,}7$ kgm/cm^2

q $K = 0{,}8$ kgm/cm^2

r $K = 0{,}5$ kgm/cm^2

s $K = 1{,}6$ kgm/cm^2

t $K = 1$ kgm/cm^2

u $K = 3{,}4$ kgm/cm^2

v $K = 4{,}4$ kgm/cm^2

w $K = 2{,}5$ kgm/cm^2

x $K = 2{,}8$ kgm/cm^2

y $K = 1{,}8$ kgm/cm^2

z $K = 1$ kgm/cm^2

Fig. 11.

Note : 1 kgm./cm^2 = 46.7 ft./lb. per sq. inch.

Using a 10-mm. (3/8 in.) ball and 3 000-kgr. (6 600 lb.) load the Brinell number shall lie between 196 and 235 for the G and GG tyres, and between 241 and 293 for the H and HH tyres.

The new specification also requires each tyre to be given a drop test (introduced in November 1932 as a result of failures during machining) to reveal hardening cracks.

These tests are made as follows :

The tyre, lifted a height depending on its inside diameter, is allowed to fall freely on a rail fixed on an anvil weighing at least two tons, so as to strike the rail on its tread. The tyre is then turned 90° and dropped a second time. The tyre shall then be free from any defect, and shall ring clearly when struck with a hammer weighing at least 1 kgr. (2.2 lb.).

[621 . 132.3 (.73)]

Chesapeake and Ohio 4-8-4 type locomotives for heavy passenger service.

(From Railway Mechanical Engineer.)

Of the few steam locomotives built in 1935 the five of the 4-8-4 type from the Lima Locomotive Works, Inc., for the Chesapeake & Ohio (C. & O.) represent the outstanding design. These locomotives, which are the first with this wheel arrangement to be used on the C. & O., are numbered from 600 to 604, inclusive, and are known as the « Greenbrier » type, or Class J-3. In addition to being numbered each locomotive has been given the name of a person who formerly lived in the territory served by the road and whose fame is nation wide. The names of those chosen were Th. Jefferson, Patrick Henry, Benj. Harrison, James Madison and Ed. Randolph.

The service for which these locomotives were designed is the handling of heavy through passenger trains on the main line between Hinton, W. Va., and Charlottesville, Va., a distance of 175 miles. Between these points the C. & O. passes over two ranges of the Allegheny Mountains and one range of the Blue Ridge Mountains. The maximum ruling grades over these ranges vary from 1.33 to 1.52 per cent and are from three to eight miles in length. The new locomotives are being used to supplement those of the present Class J-2, U. S. R. A.

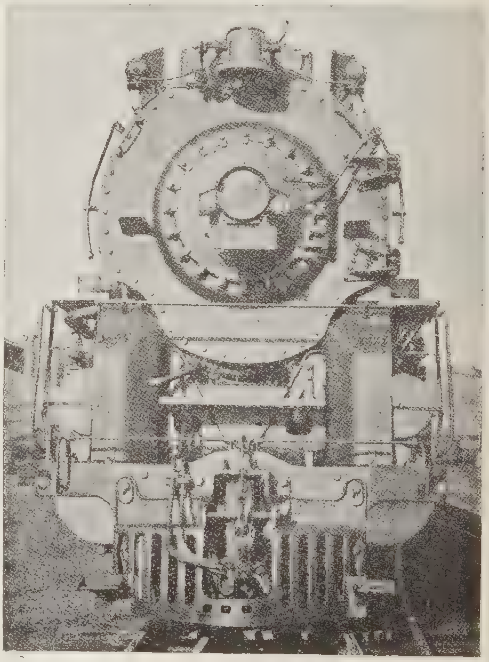


Fig. 1. — Front view showing drop coupler.

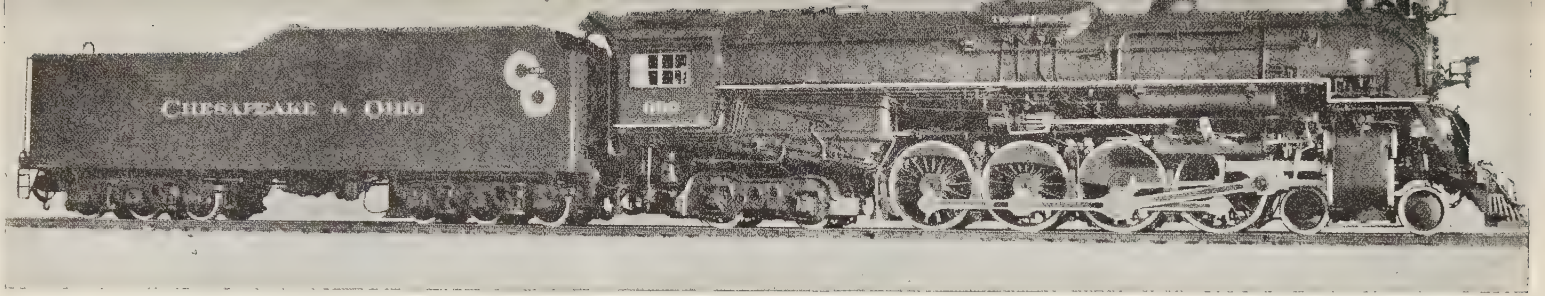


Fig. 2. — Side view.

General dimensions, weights and proportions.

Railroad	C. & O.
Builder	Lima Loco Wks. Inc.
Type of locomotive	4-8-4
Number of locomotives	5
Road class	J-3
Road numbers	600-604
Date built	1935
Service	Passenger
Dimensions:	
Height to top of stack, ft. and in.	15 — 4 1/2
Height to center of boiler, ft. and in.	10 — 5 1/2
Width overall, in.	126
Cylinder centers, in.	91 1.2
Weights in working order, lb.:	
On drivers	273 000
On front truck	89 500
On trailing truck	53 000 front 61 000 back
Total engine	477 000
Tender, loaded	381 700
Wheel bases, ft. and in.:	
Driving	19 — 3
Rigid	12 — 10
Front truck, in.	88
Trailing truck, in.	78
Engine, total	46 — 10 1/2
Engine and tender, total	98 — 5 1/4
Wheels, diameter outside tires, in.:	
Driving	72
Front truck	36
Trailing truck	36 and 44
Engine:	
Cylinders, number, diameter and stroke, in.	2 — 27 1/2 × 30
Valve gear, type	Walschaerts
Valves, piston type, size, in.	14

Maximum travel, in.	7 1/2
Steam lap, in.	1 9/16
Exhaust clearance, in.	3/16
Lead, in.	1/4
Cut-off in full gear, per cent	79.7
Boiler:	
Type	Conical
Steam pressure, lb. per sq. in.	250
Diameter, first ring, outside in.	91 11/16
Diameter, largest outside, in.	100
Firebox, length, in.	150 1/16
Firebox, width, in.	96 1/4
Height mud ring to crown sheet, back, in.	67 1/2
Height mud ring to crown sheet, front, in.	95 3/4
Combustion chamber length, in.	54
Arch tubes, number and diameter, in.	2 — 3 1/2
Thermic syphons, number	2
Tubes, number and diameter, in.	65 — 2 1/4
Flues, number and diameter, in.	220 — 3 1/2
Length over tube sheets, ft. and in.	21 — 0
Net gas area through tubes and flues, sq. ft.	10.6
Fuel	Soft coal
Grate area, sq. ft.	100
Heating surfaces, sq. ft.:	
Firebox and combustion chamber	396
Arch tubes and Thermic syphons	129
Firebox, total	525
Tubes and flues	5 013
Evaporative, total	5 538
Superheating (type E)	2 342
Combined evap. and superheat.	7 880
Tender:	
Style or type	Rectangular
Water capacity, U. S. gall.	22 000
Fuel capacity, tons	25

Trucks	6-wheel
Journals, diameter and length, in	7 × 14
General data, estimated:	
Rated tractive force, main engine, lb.	66 960
Rated tractive force, booster	14 075
Total rated tractive force, lb.	81 035
Speed at 1 000 ft. per min. piston speed, m.p.h.	42.85
Piston speed at 10 m.p.h. ft. per min.	236
R.p.m. at 10 m.p.h.	46.7
Boiler evap. (with heater) (Cook) lb. per hr.	79 640
Equiv. evap. per sq. ft. evap. h.s. per hr.	14.38
Weight proportions:	
Weight on drivers ÷ weight engine, per cent	57.2
Weight on drivers ÷ tractive force.	4.08
Weight of engine ÷ evaporation	5.99
Weight of engine ÷ comb. heat. surface	60.53
Boiler proportions:	
Firebox h.s. per cent comb. h.s.	6.7
Tube-flue h.s. per cent comb. h.s.	63.6
Superheat. surface per cent comb. h.s.	29.7
Firebox h.s. ÷ grate area	5.25
Tube-flue h.s. ÷ grate area	50.13
Superheat. surface ÷ grate area	23.42
Comb. h.s. ÷ grate area	78.80
Gas area, tubes and flues ÷ grate area	0.11
Evaporation ÷ grate area	796.4
Tractive force ÷ grate area	669.6
Tractive force ÷ evaporation	0.84
Tractive force ÷ comb. h.s.	8.50
Tractive force × dia. drivers ÷ comb. h.s.	6.12

heavy 4-8-2 type, now in passenger service in this territory. They will haul such trains as the George Washington, the Sportsman and the F. F. V., all of which are composed of modern, all steel, air-conditioned Pullmans, day coaches and tavern-type diners.

These locomotives have the largest combined heating surface of any locomotive of this type thus far built; namely, 7 880 sq. ft. The high total and the relatively high percentage of radiant heating surface is relied upon to produce a heat transfer which, combined with care throughout the design to effect high economy in the utilization of steam in the cylinders, is expected to provide a locomotive capable of developing not less than 5 000 cylinder horsepower.

The boiler.

The boiler, which carries a pressure of 250 lb. per sq. in., but is designed for a maximum of 260 lb., is of unusually generous capacity and, using the Cook formula, has an estimated evaporative capacity of 79 640 lb. per hour, including an eight per cent allowance for the feedwater heater. In addition, the design provides the largest steam space possible within the clearance limit.

The shell, which is of the conical type, is made up of three courses of nickel steel. The first is 91 11/16 in. in outside diameter and 27/32 in. thick; the second, which is tapered, is 29/32 in. thick, and the third, which extends to the throat, is 100 in. in outside diameter and 15/16 in. thick. The firebox, which has a combustion chamber 54 in. long, contains two Thermic syphons which are supplemented by two arch tubes for the support of the Security brick arch. The crown sheet has a slope of 8 1/4 in. and a space of 29 1/2 in. is provided between the crown sheet and the roof sheet. There are 65 2 1/4-in. tubes and 220 3 1/2-in. flues, the length over tube sheets being 21 ft. The dome, with an opening 32 in. in dia-

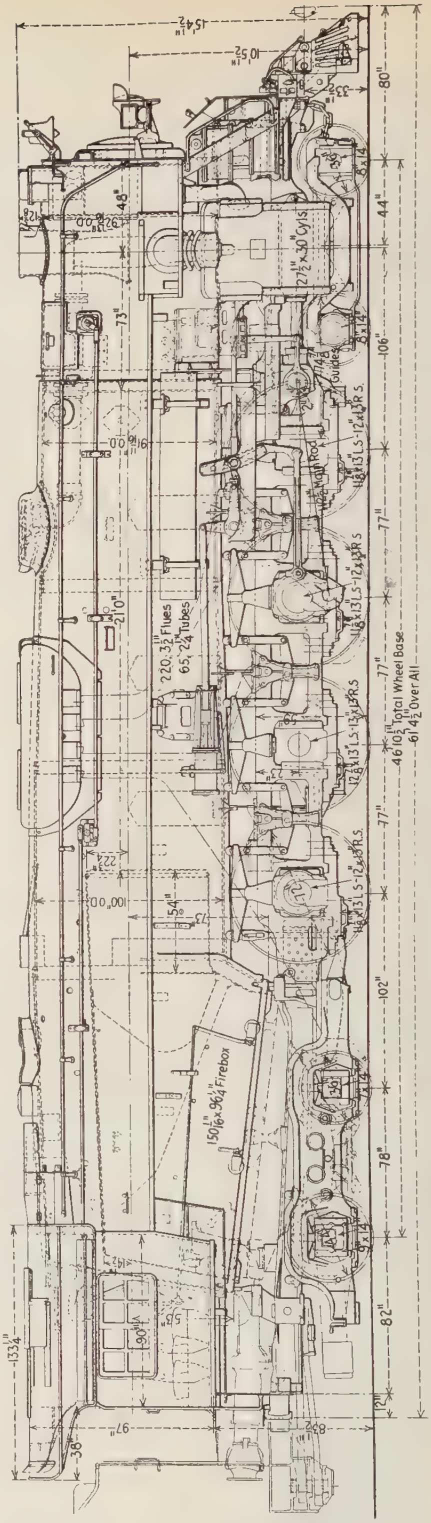


Fig. 3. — Elevation.

meter and a height of only 9 in., is located on the first shell course, 6 ft. 7/8 in. back of the tube sheet. The total length of the boiler, including the smokebox which is 121 in. long, is 49 ft. 5 1/4 in.

The grate has an area of 100 sq. ft. and a slope from back to front of 20 in. The grates are of the firebar type and the coal is fed by a standard type MB stoker. Six combustion tubes are provided, three on each side.

The boiler is fitted with the Elesco type E superheater, with the American multiple throttle and a Worthington type 5-S feedwater heater of 9 000 gall. capacity. The drypipe is of 10 1/2 in. inside diameter. Superheated steam is used for the blower. All other auxiliaries are operated by saturated steam taken from a cast steel cab turret. The safety valves are mounted on a cast-steel turret attached to the roof sheet.

Welding has been employed at many points in the construction of the boiler. In the firebox the crown sheet is butt-welded to the side sheets, the bottom sheet of the combustion chamber is butt-welded to the crown sheet, the Thermic syphons are welded to the crown and throat sheets, the inside throat sheet is butt-welded all around, the firedoor sheet seams are butt-welded from the bottom of the mud ring up to the center line of the boiler and the firedoor hole seam is butt-welded. The mud ring calking edges are seal welded to both inside and outside sheets for a distance of 24 in. from each side of the center line of the corner, except at the front where the outside sheet is seal welded longitudinally for 40 in. back from the corner. The back head seams are sealed by welding from the bottom of the mud ring to the top of the seam between the outside wrapper and the side sheets, and side-sheet seams are seal welded at the throat connection from the bottom of the mud ring on one side over the top of the boiler and down to the bottom of the mud ring on the other side, the throat seam to the third sheet course is completely seal welded, the longitudinal boiler seams are seal welded at each end for a distance of 12 in., and the outside butt-strap on the third course longitudinal seam is seal welded in the stayed zone of the combustion chamber. In addition, the combustion tubes are seal welded on the fire side, all tubes and flues are welded at the firebox end and the staybolt MK caps and UW sleeves are welded.

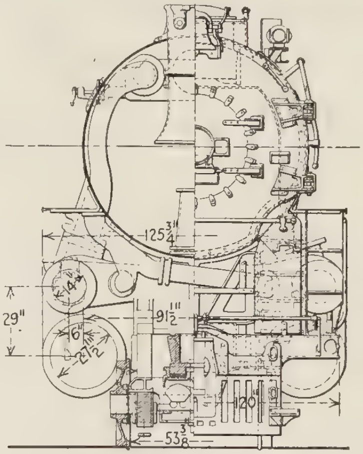


Fig. 4. — Cross section.

The cylinders are 27 1/2 in. in diameter by 30 in. stroke. With 250 lb. boiler pressure and 72-in. drivers a rated tractive force of 66 960 lb. on an 85 per cent basis is thus provided. A Franklin type C-2 long cutoff booster with slip control and check valves is applied to the trailing truck. This adds 14 075 lb. to the tractive force, bringing the total for the main engines and the booster up to 81 035 lb. The exhaust from the booster is piped to an integral passage cast in the front side of the smoke stack.

The two cylinders, spaced on 91 1/2-in. centers, are annealed carbon-steel castings of the half-saddle type with 14-in. piston valves having a maximum travel of 7 1/2 in. The steam lap is 1 9/16 in., the exhaust clearance 3/16 in., and the lead 1/4 in. Steam and exhaust passages are direct and of large area to reduce the losses due to drop in steam pressure and back-pressure resistance. Flextite steam pipe casings are provided. The back cylinder heads are separate castings. Conventional bolting of the cylinder castings is supplemented by electric welding at the saddle splice joint and at the frame fits. The valves are operated by Walschaerts gear under control of an Alco type E reverse gear. The crossheads and guides are of the multiple-bearing type.

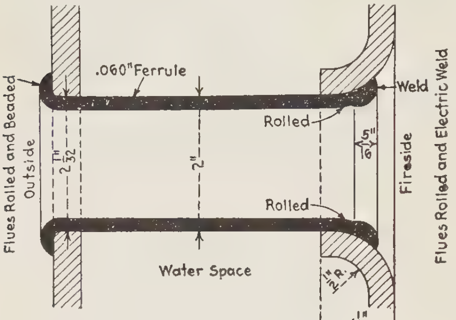


Fig. 5. — Detail construction of the combustion tubes.

The frames are of the bar type, each a separate annealed carbon-steel casting and joined together by the conventional type of transverse cast-steel bracing, with a cast-steel deck plate at the front and a steel cradle casting under the firebox. The pilot is of the cast-steel type and provided with a pocket into which the front coupler may be dropped when not in use.

The first, third and fourth driving axles have 11 7/8-in. by 13-in. journals on the left side and 12-in. by 13-in. journals on the right side. The second, which is the main driving axle, has 12 7/8-in. by 13-in. journals on the left side and 13-in. by 13-in. journals on the right side. This difference of 1/8 in. in right- and left-hand journals on the same axle is in accordance with the general practice on the C. & O. and permits of shifting crown brasses from one side to the other as wear takes place. This same practice is also applied to crank pins. All axles, crank pins and rods are open-hearth carbon steel forgings, normalized and annealed. The Alco lateral cushioning device is applied to the front driving boxes. The locomotives are fitted with tandem main rods operating on the crank pins of the second and third pairs of wheels. This design of side rods requires no knuckle pins.

All axle journals, crank pins and guides have been provided with ample bearing areas so that all bearing pressures on these locomotives and tenders are exceptionally low.

The four-wheel leading truck is of the General Steel Castings constant-resistance rocker type, with inside journal boxes. The four-wheel trailer truck is of the Delta type.

Force-feed lubricators furnish oil to the guides, the steam chests and cylinders, the engine truck boxes, the air

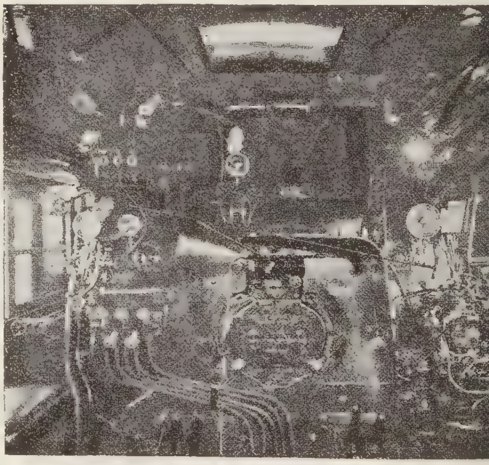


Fig. 6. — View in cab of back boiler hea and fittings.

pumps and the hot-water feedwater pump. The mechanical lubricators on three of the locomotives are the Detroit 32-B type, and on two, the Nathan 24-pint, 16-feed type. A three feed, three-pint hydrostatic lubricator is provided for the booster and the stoker engine.

The locomotives are provided with New York No. 6-ET brake equipment, including two 8 1/2-in. cross-compound air compressors, mounted on the front deck on brackets extending under the front end of the smokebox. They are equipped with the Union Switch & Signal Company's intermittent induction type train control.

The rectangular water bottom tender has a capacity for 25 tons of coal and 22 000 U. S. gallons of water. It is carried on two Buckeye type, six-wheel trucks and has a loaded weight of 381 700 lb. The stoker engine is housed in the left side of the tender in a compartment set in the front water leg. The Franklin Unit Safety drawbar and the type A-1 radial buffer are provided between the engine and tender. Simplex brakes are applied to the trucks.

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Main-line electrification throughout the World,(1)

by E. R. KAAN,
Elektrisierungs Direktor, Austrian Federal Railways.

(Electric Railway Traction, supplement to *The Railway Gazette.)*

Among the measures adopted by railways to improve their economic situation, the introduction of electric traction in many railways in almost all civilised countries holds a unique position. The first reasons for electrification are what may be called internal considerations of the railway companies, and the second considerations concerning the requirements of the countries as a whole. It is possible, however, that both reasons may be co-existent.

To the first class belong considerations of an economic character regarding the technical requirements of the service. Among these are the necessity for reducing the costs of the service; increasing the capacity of the system; raising the speed of all types of trains; reducing the costs of passenger transport; subdividing and increasing the service by means of appropriate electric railcars; obviating the necessity of doubling the tracks (which work would have to be carried out if steam traction were retained) or extending stations, especially termini; improving the suburban service of large towns, which could not be done with steam traction if the traffic became any heavier; shortening the new lines, since electric traction permits the construction of steeper gradients; and the like.

To the second class belong the following : Railway electrification finds employment for many, especially for skilled labour. It enables a country which lacks coal to be independent of foreign coal, which improves the commercial balance; the regularity of the traffic is not liable to suffer from stoppages of coal imports from abroad in consequence of strikes, political disturbances, or even wars in or with other countries. In addition, any water-power stations in a country may be more efficiently utilised; tourist traffic is improved; and mobilisation in case of war is facilitated.

(*) Abstract of a paper read before the Institution of Electrical Engineers, April 30, 1936.

THE WORLD'S RAILWAY ELECTRIFICATION. MAIN LINES ONLY.

CONTINENT.	Track kilometrage electrified.				
	Direct current		Single-phase		Three-phase
	1 200-1 500 V	2 400-3 000 V	11 000 V	15 000 V	3 700 V
Europe	3 500	1 600	...	7 800	2 140
America	650	2 180	1 430	150	...
Asia	950	...	...	...	...
Africa	...	900	...	...	...
Australasia	170	...	...	...	...
	5 270	4 880	1 430	7 950	2 140
	10 150		9 380		

Electric traction on main lines employs two systems mainly. The first is the single-phase alternating-current system, generally 16 2/3 cycles, and a voltage at the contact line of 15 kV. The other is the direct-current system, generally at a voltage of 3 000 or 1 500 at the overhead equipment. In addition the three-phase system of 3 600 volts at the overhead equipment is used in a few cases, and lately also a system has been introduced with single-phase alternating current at the overhead equipment, which is obtained from a three-phase 50-cycle supply by conversion on locomotives or in substations, in both cases by means of grid-controlled mercury-arc rectifiers.

Switzerland.

Switzerland has progressed further with electric traction than any other European country. Apart from the Federal Railways, there are in Switzerland a number of private companies which carry a large amount of traffic. Without exception, these employ electric traction.

The Swiss Federal Railways started with an extensive programme of electrification, which was completed by the end of 1928 and comprised 1 040 route miles, so that 57.8 % of all the system was electrified, but 85 % of the traffic (in gross ton-miles) was operated by electricity. The satisfactory experience gained with electric traction caused the Swiss Federal Railways, in 1929, to continue the electrification, which includes a further 315 route-miles. By the middle of 1936, 75 % of the system will be electrified, corresponding to about 92.5 % of the gross ton-miles to be hauled. The Swiss Federal Railways operate their lines with single-phase alternating current at 15 kV. and 16 2/3 cycles. They considered it expedient to obtain the greater part of their energy for the electrified system from the seven water-power stations owned by the railway. Altogether, 491 electric locomotives are used for haulage on lines of widely differing types of construction, 21 locomotives for shunting, and 48 electric railcars. The energy used amounts to 520 000 000 kWh. a year, 80 % of which is generated in railway-owned power stations.

Amsteg hydro-electric power station of the Swiss Federal Railways. This view shows also the viaduct carrying the St. Gothard line over the ravine.

Germany.

The original reason for electrification on the German State Railways was the rationalisation of the service. In recent years, however, considerations of national and political economy became the deciding factors; these are mainly the occupation of the highly developed German industry and the relief of unemployment.

In southern Germany, Bavaria, Würtemberg, and Baden the energy is obtained from water-power stations, which in most cases do not belong to the Reichsbahn but are mainly State-owned. The second district is in central Germany between Leipzig, Halle, and Magdeburg, and obtains its power from brown-coal power stations. The third is in Silesia. In this district the energy is principally obtained from a steam power station, which consumes coal raised on the spot; this, however, is of low calorific value and cannot easily be used for any other purpose. The fourth district is situated in and around Berlin, and comprises the Berlin Stadt, Ring, and Vorortbahnen. The power needed for this system is obtained from privately-owned steam stations. The fifth district comprises the metropolitan and suburban lines of Hamburg. These obtain their supply partly from a railway-owned power station and partly from a privately-owned station. Among the lines that have recently been electrified, the Munich-Augsburg-Stuttgart and Augsburg-Nuremberg lines are of the greatest importance. The electrification of the last-named line is to be extended via Halle and via Leipzig as far as Berlin. Thus an electric connection between Munich and Berlin will be established and a connection from north to south from Berlin via Munich, Innsbruck, Rome, and Naples, to the southernmost points of Italy, will be completed.

The single-phase 16 2/3-cycle system, with 15 kV. at the overhead equipment, was selected for the entire system of the Reichsbahn, with he exception of the Berlin lines which use D.C., and the Hamburg metropolitan, which is operated with single-phase at 6 kV., 25 cycles.

Two more exceptions are the lines in the Black Forest, the Höllentalbahn and the Dreiseenbahn, which branches off near the health-resort of Titisee. The power for these lines is obtained from the general supply system (50 cycles) of the country by means of Scott-connected transformers. The alternating current at the overhead equipment is supplied to the traction motors by means of grid-controlled mercury-arc rectifiers. This will provide useful information as to the use of such rectifiers for railway operation.

Sweden.

The following figures give a survey of the importance of electric traffic on the Swedish State Railways. In July, 1935, 1 380 miles were electrified; a short time ago another 142 miles were added, so that 1 522 miles have been worked electrically since the end of last year. By June, 1937, the mileage will amount to 2 600, and the electrification of a further 680 miles is being proposed. The fact that 30 track-miles a month are being converted is characteristic of the speed with which the work is carried out. The work already done or scheduled for electrification comprises 40 % of the entire length of the Swedish State Railways, but these lines carry more than 80 % of the coach axle-miles. After the work proposed to the Government by the State Railway administration has been carried out, these percentages will rise to 60 and 95 respectively.

The Swedish State Railways are supplied with power obtained from water-power stations scattered all over the country. These are chiefly the property of the State, only a very small proportion being privately owned. It is of interest to note that the Swedish State Railways have lately adopted the so-called movable convertor stations, the transformers being installed in one car, while the convertor is installed in a second. This system has certain advantages, but is not without drawbacks. Certain conditions, however, peculiar to the Swedish State Railways, are responsible for this arrangement.

Norway.

In this country 137 of the 2 200 miles of the State Railways are electrified. With the exception of the Ofotenbahn, 26 miles in length, which continues the Swedish Riksgränsenbahn on Norwegian territory as far as Narvik, all the lines are in the southern part of the country. Part of the energy is generated in the

Hakavik power station, and part is converted from a three-phase supply. Electrification on the lines, which in some places have gradients of 1 in 38, was so satisfactory that, as the result of a decision of the Storting, electric traction will be introduced on a further 75 miles of the system.

Austria.

Even before 1914 the question of railway electrification had been studied in Austria. But owing to the fact that the Austria of those times had extensive hard-coal fields at her disposal, the matter was not considered urgent. Only two standard-gauge lines were electrified; these were the Mittenwaldbahn in the Tyrol, in 1912; and the Vienna-Bratislava line, in 1914.

In 1918 the situation in Austria became difficult owing to the dependence on the import of foreign coal for the railway service. She was therefore driven to exploit the natural resources at her disposal and to introduce electric traction, taking the supply from hydro-electric stations. In 1920, the Austrian Parliament decided on an extensive scheme of electrification, which, amended by a further bill in 1925, provided for the electrification of all the lines of the Federal Railways west of Salzburg to the Swiss frontier, and also the line from Stainach-Irdning to Attnang-Puchheim. Electric traction had been introduced on about 136 miles of the Austrian railways before the war, and it was extended a further 439 miles after the war, so that 575 miles, or 16 % of the total, are now electrified. These lines carry 22 % of the entire traffic of the Federal Railways.

The system chosen is the single-phase alternating current at 15 kV. 16 2/3 cycles at the contact wire. The supply is obtained mainly from four railway-owned water-power stations. About 306 miles of transmission lines at 55 kV. and

Two views of the 15 kV. single-phase lines of the Austrian Federal Railways.

about 770 miles of contact wires were constructed. 178 locomotives and 12 electric motor-coaches are in service. Four large locomotive sheds were built, in addition to a locomotive repair shop attached to a central repair shop. The whole enterprise formed the largest single item of constructive work carried out in Austria in post-war times; the cost amounted to more than £ 13 000 000.

It is the intention of the Austrian Federal Railways to continue the electrification with a view to providing work for the highly developed industry of the country. A great programme has been devised, comprising the Salzburg-Vienna line, the southern railway as far as Graz, the eastern railway to the Hungarian frontier, and some other lines of less importance. Also the introduction of electric traction on the suburban lines of Vienna is under consideration. A necessary condition for the realisation of the programme is the raising of funds by means of a loan on easy terms. To commence with, it is proposed to electrify the Salzburg-Vienna line, 191 miles in length.

Hungary.

The Kandó system of electrification differs fundamentally from all other systems, and has hitherto been used exclusively by the Hungarian State Railways on the Budapest-Hegyeshalom route and on the Budapest-Alag trial line. The Kandó scheme is based on the idea of using, without conversion, three-phase current, which is the general supply system of the country, though it uses single-phase current of the same frequency as the three-phase system, *i. e.*, 50 cycles. In Bánhida was erected a large power station for general supply, burning inferior, earthy coal raised in the vicinity and not worth transporting. In this power station three sets of turbo-generators of 30 000 H.P. each were installed. The voltage generated is stepped up to 110 kV. and conducted by means of a transmission line consisting of two systems with three cables each to the four substations of the railway. Each substation has two single-phase transformers with a continuous rating of 4 000 kVA., which can be increased to 8 000 kVA. These transformers step down the voltage to 16 kV., which is fed to the overhead equipment.

Italy.

Approximately 870 miles of the private railways, which comprise a total of about 3 100 miles, are electrically operated. On the State Railways two systems of supply are in use. With the exception of a few earlier test-lines the three-phase system at 3 600 to 3 700 volts and 16 2/3 cycles is used in northern Italy, while D.C. at 3 000 volts is used in central and southern Italy. The extent of the present

The passing place in the Apennine tunnel on the 3 000-volt D.C. Direttissima between Bologna and Flo electric operation may be gathered from the following figures : 1 330 miles of line are operated with the three-phase system, and 767 miles with the D.C. system, a total of 2 097 miles. The electrification of 1 640 miles of double track and 1 076 miles of single track lines, 2 716 miles in all, has been decided upon.

The greater part of the energy is obtained from water power stations, two-thirds of which are railway-owned and one-third privately owned. The transformation and conversion, respectively, of the energy supplied by transmission lines at 60 to 150 kV. are carried out by transformer stations for the three-phase system, and for the D.C. lines in substations by means of mercury-arc rectifiers.

Poland.

In Poland the first electrification was introduced in 1927 on a suburban line of Warsaw, 20 miles in length. At present 60 miles of suburban lines are being electrified. The work is being carried out by English firms with English capital. Direct current at 3 000 volts was selected, and this is converted from three-phase current obtained from a private company in Warsaw. The intention is to use electricity for passenger trains, while goods trains will be steam-driven. It has been calculated that an annual saving of 20 % will result. On expert advice electric traction was also proposed for several main lines. From an economic point of view the electrification of a total of 1 120 miles is justified.

Rumania.

The electrification of the Campina-Kronstadt section of the State Railways was proposed some time ago, the main reason being that the capacity of this single-track mountain-line would be increased. As the electrification would enable the construction of a double track to be postponed for some time, it would be justified from the economic point of view. The scheme has been shelved for the time being owing to a great reduction in traffic, but it will come to the fore again as soon as economic conditions improve.

Czechoslovakia.

Electric traction was introduced in 1928 solely for the stations and tunnel tracks of Prague, comprising 50 miles of track. Direct current at 1 500 volts was used, being converted from the municipal three-phase system of Prague. When this electrification was projected it was considered that electric traction would be generally introduced. Great power stations near the coalfields, burning waste coal, were to supply the necessary power. There seems to be no likelihood, however, that this scheme will be realised in the near future.

U.S.S.R.

In this country the mileage of electrified lines was about 300 at the commencement of 1935. On about 600 miles of track the necessary constructional work is being carried out. As far as the author is aware, an aggregate of 3 180 miles of track is to be electrified by the end of 1937, 2 240 miles of which are main lines, mostly in the south. On the Batum-Tiflis line, the Zestafoni-Chasburi section, 40 miles in length and with gradients up to 1 in 34, has been in operation since 1933. The suburban lines to be electrified by 1937 will cover a mileage of 350.

Denmark.

The scheme for the electrification of the suburban lines near Copenhagen, projected in 1926, came into force by a bill passed in 1930. Conversion was commenced in the course of the same

Overhead construction on the 1 500-volt D.C. lines of the Danish State Railways, near Copenhagen.

year. A total of 24 miles was electrified at 1 500 volts D.C., which is converted in four rectifier substations from three-phase current at 10 kV. 50 cycles, supplied by a privately owned grid.

Holland.

Electric traction was introduced in this country in 1908, on the Rotterdam-The Hague-Scheveningen line, with 11 kV. 25-cycle single-phase current. In view of the satisfactory results it was decided in 1918, to continue the electrification. Direct current at 1 500 volts was finally selected, necessitating alterations on the Rotterdam-Scheveningen line. Up to the present 142 miles have been electrically equipped.

Barendrecht station on the 1 500-volt D.C. lines of the Netherlands Railways.

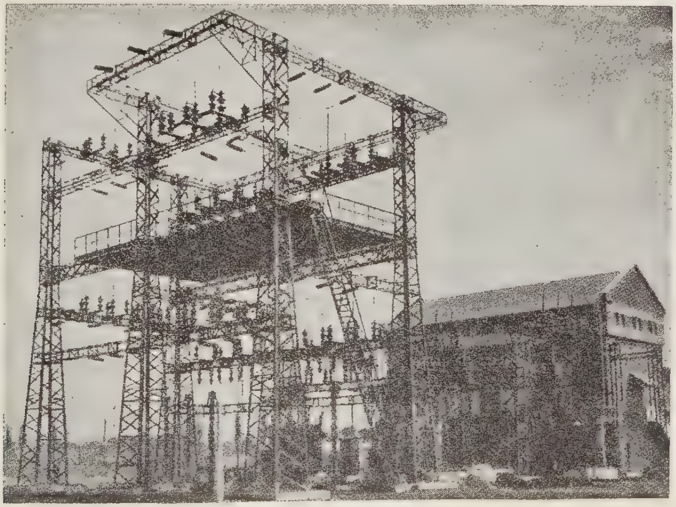
The three-phase current supplied by privately owned stations is converted in 19 substations, in which, with two exceptions, rectifiers are installed. Owing to the heavy local traffic, multiple-unit trains are exclusively used as means of traction. The trains for through traffic, as well as the freight trains, are still hauled by steam locomotives. The results obtained with electric traction are very satisfactory both from the technical and economic points of view ; the volume of traffic has risen considerably on the electrified lines.

Belgium.

Until recently electric traction has been confined to the secondary lines of this country. The National Light Railways Company, which controls 2 880 miles of lines, operates more than one-fifth by means of electricity. Recently more attention has been paid to electric traction on main lines, since its economic advantages have been repeatedly proved. The Belgian National Railways Company, which runs nearly all main lines, has electrified the Antwerp-Brussels line. Later, the electrification will be extended to the Brussels-Arlon and Marloie-Liége lines. Altogether 193 miles of lines are to be equipped for electric traction to start with. A contact-wire voltage of 3 000 was selected, the current being obtained from steam-power stations.

France.

The mileage of electrified lines amounts to 1 310. The greater part belong to the Paris-Orleans and Midi Companies, which amalgamated in 1934. The main lines running from Paris by way of Orleans to Tours, and from Orleans to Vierzon and Brive, have already been electrified.



Outdoor high-tension gear bringing 90 kV. three-phase current into a substation on the P. O.-Midi main line.

The Tours-Bordeaux line, 220 miles in length, which is to be electrified under the Marquet scheme, will extend the service from Paris to those lines of the Midi Railway that are already electrically operated. This company has electrified the majority of its lines in the Pyrenees, and also the Bordeaux-Pointe de Grave, Béziers-Neussargues, and Montauban - Toulouse - Narbonne - Sète lines. The Brive-Montauban and Bordeaux-Montauban lines are scheduled for electrification.

Spain.

The railway system of this country comprises 10 440 miles of lines, 557 miles of which are electrically operated. The most important belong to the Spanish Northern Railway which have electrified more than 250 miles, i. e., 9 % of their system. The lines are mainly in the northern part of the country and form sections of the most important transit lines from north to south. They run through mountainous districts and in some parts have to negotiate heavy gradients. They are operated mainly with D. C. at 1 500 volts obtained from a three-phase supply, partly by means of rectifiers. The energy is supplied from water-power plants.

The electrification of the main line from Madrid to Avila in the north, with the branch line to Segovia, has been authorised. There are 90 miles of double-track and 41 miles of single-track with long gradients up to 1 in 60. The contact-line voltage will be 1 500. The energy will be obtained from four undertakings which supply central Spain with energy, and from the recently built power station of Saltos del Duero, near the French frontier, which has a capacity of 160 000 H.P.

Northern Africa.

In the French colonies of Northern Africa almost 440 miles have already been converted to electric traction. The greatest advance in this direction has been made by the railways of Morocco. The ultimate aim within the next 10 years or so, is the electrification of the Marrakech-Tunis line, and 350 miles out of a total of 1 500 have already been completed.

So far as the railways of Morocco are concerned, the western part of the system from Marrakech to Petit Jean and Fez has been converted to 3 000 volts D.C. The electrification was commenced in 1927, and 344 miles have been completed. A steam-power station in Casablanca and a water-power station in Sidi-el-Aida supply the necessary energy.

The Algerian Railways have electrified the Duvivier-Oued Keberit section of the Bone-Tebessa line. The work was carried out in 1929-33. This section comprises 67 miles, and D.C. at 3 000 volts is used. The line, on which are heavy gradients and numerous tunnels, mainly serves to transport minerals and had already reached the limit of its capacity when operated with steam.

South Africa.

Electric haulage in South Africa comprises the suburban traffic near Cape Town and the main line in Natal. The electrification of the Daimana-Harrismith section is completed, and a further extension of the line from Cato Ridge towards the south as far as the coast, and from Glencoe in a northerly direction as far as Johannesburg, is under way. A voltage of 3 000 was chosen to operate long-distance traffic; this is transformed down from three-phase current at 88 kV. in unattended substations.

Turkey.

In Turkey the questions whether to introduce electric traction, together with the projected construction of a new line along the Black Sea, are under consideration. The proposed line will run from Eregli (the ancient Heraclea) along the coast as far as Filyas, and from there inland to Karabük, the total length of line being 100 miles. The aim is to connect the seaport of Eregli with the coalmines near the Black Sea, and with Karabük, which will become the centre of an iron industry to be created there. The traffic is extremely heavy; it is estimated that 15 trains of 1 200 tons will be run in each direction daily, merely for the coal transport from Catalagsi to Eregli. The energy required will be obtained from a steam-power station to be erected near the coalmines. The original scheme only provided for a line from Eregli to Catalagsi, for the electrification of which direct current at 3 000 volts was projected, but now that the programme has been extended, single-phase alternating current at a contact voltage of 15 kV., and 16 2/3 cycles, may be adopted.

India.

In British India about 625 miles of the entire railway system of 47 000 miles are electrified; they comprise suburban lines as well as long-distance lines. Among the latter, the most noteworthy is the line running inland from Bombay. Near Kalyan, about 25 miles from Bombay, the line forks into two branches, one of which runs to the north-east by way of Igatpuri, the other to the south-east via Poona. The Bombay electric suburban service was started in 1929. 1 500-volt direct current was chosen for the contact wire. The energy is supplied by a water-power and a steam-power station by means of 100-kV. transmission lines. The extension of the electric service beyond Igatpuri and Poona to a distance of about 1 030 track miles is projected.

Japan.

Electric traction in this country dates back to 1895, when a line of 6 1/2 miles near Kyoto was electrified. Today, 220 miles, or 2.3 %, of the State lines, and 4 200 miles, or 58 %, of the local lines, are electrified. Only D.C. is used, at 1 500 volts for long-distance service and at 600 volts for the local services. Most of the energy is obtained from privately-owned stations, and is converted partly by means of rotary convertors, but mainly by mercury-arc rectifiers.

South America.

In South America it was Brazil which first introduced electric traction. This was in 1921 on the Paulista Railway, over a length of 179 miles, for which D.C. at 3 000 volts was chosen. In 1927 the Western Minas Railway, 45 miles long, was electrified at 1 500 volts D.C.

3 000-volt d.c. line
of the Paulista Railway, Brazil.

The satisfactory results obtained led in 1935 to a preliminary settlement of a contract between the Brazilian Government and the Metropolitan-Vickers Electrical Co. Ltd., for the electrification of the Central Railway from Rio de Janeiro to

Barra do Pirahy and Santa Cruz with D.C. at 3 000 volts. The total route mileage is 94 and the cost was estimated at £ 3 000 000. The electrification is to be extended to other lines.

In Chili, in addition to three short sections, two other lines were electrified : in 1924 the Santiago-Valparaiso-Los Andes State Railway line, 145 miles in length, with a wide gauge, and in 1927 the Trans-Andean Railway. Both lines are operated with D.C. at 3 000 volts. The energy is supplied by water-power stations which obtain their water from the Andes.

Central America.

The only State line in Costa Rica, 92 miles long, connects the capital, San José, with the seaport town of Puntarenas. The line has long gradients up to 1 in 40, and is single-phase, 15 kV. 20 cycles.

In Guatemala only the steep mountain railway from San Felipe to Quezaltenago, 27 1/2 miles in length and with normal gauge, is electrically operated (*). Direct current at 1 500 volts is employed for the contact wire and is converted in rotary convertors from three-phase current generated in a water-power station. This line is remarkable for the fact that there are gradients of 1 in 11 and of a length of almost 10 1/4 miles. This is proof that electric traction increases the range of use of adhesion railways.

United States.

Not quite 1 % of the 262 500 miles of lines in this country have been electrified. Electric traction is distributed among no fewer than 21 railway companies, and dates back to the year 1887. Direct current at 3 000 volts, and single-phase current at 11 kV. 25 cycles, are mainly used for main lines. In addition, some extensive systems are equipped with D.C. at 650, 1 500, and 2 400 volts. For single-phase traction, locomotives with commutator motors are used in addition to convertor locomotives, for which the single-phase current supplied is converted either by split-phase convertors, or by single-phase D.C. convertors. Until recently the Chicago, Milwaukee, St. Paul & Pacific Railroad had the most extensive system, some 875 miles in length. It is operated with D.C. at 3 000 volts. The Delaware, Lackawanna & Western Railroad built its lines for the same voltage. This company was the first to use exclusively mercury-arc rectifiers and multiple-unit trains with D.C. at 3 000 volts.

A passenger train on the 11-kV. 25-cycle single-phase system of the Pennsylvania Railroad.

(*) Since its construction. — Ed. *R. G.*

During recent years the Pennsylvania Railroad has electrified its lines extensively. In 1928 it was decided to convert the main line from New York via Philadelphia as far as Wilmington, and the lines running towards the west to the Susquehanna River with single-phase current at 11 kV. 25 cycles at the contact wire. This necessitated the conversion of the lines in the vicinity of New York, which had until then been operated with D.C. at 650 volts, to single-phase current. In 1929 the Wilmington-Washington line was included in the scheme. The electric service of the Pennsylvania Railroad is thus the most extensive in the world. The New York—Washington line is 225 miles in length. It is a double-track line the whole way, but sections of it have even four and six tracks. The traffic is extraordinarily heavy, 60 freight trains and 830 passenger trains running daily; 492 passenger trains are multiple-unit sets which serve the interurban traffic of New York, Philadelphia, Baltimore, and Washington. At the present time 1 080 miles of the Pennsylvania Railroad are electrified. Thirty-three substations with capacities of 9 000 to 27 000 kV. supply the line. When the scheme is in full operation, 800 million kWh. will be consumed for traction purposes.

[621 .43 (.73)]

Diesel-electric freight locomotive,
built by the Westinghouse Electric & Manufacturing Co.

(Railway Mechanical Engineer.)

A 1 600-H.P. 133-ton diesel-electric locomotive has been completed by the Westinghouse Electric & Manufacturing Company. The specifications drawn up before the locomotive was built required that the total weight be carried on four driving axles, that the mechanical features be sufficiently simple and durable

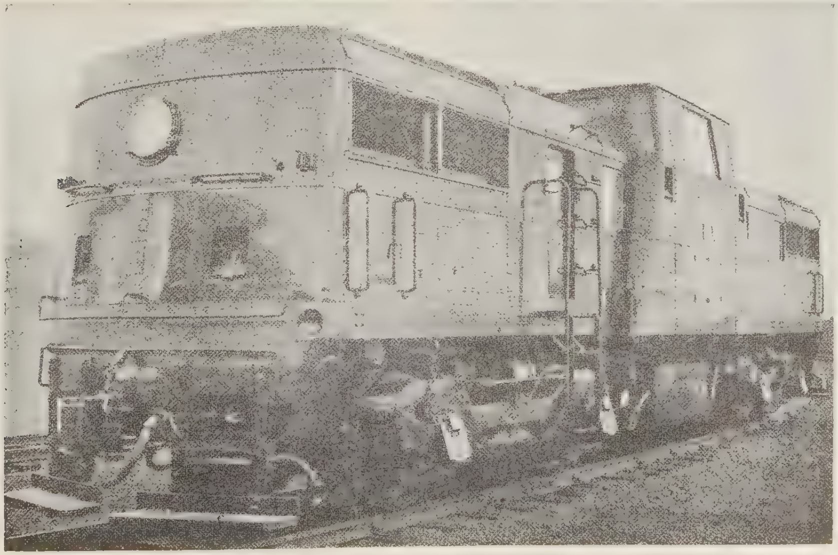


Fig. 1. — The Westinghouse 1 600-H.P. diesel-electric locomotive for freight service.

to meet the most severe freight-service requirements, that all ordinary maintenance of power plant and auxiliary apparatus could be carried out without dismantling the cab structure, and that the unit be suitable for one-man operation.

The locomotive consists of a visibility-type cab and two equipment hoods mounted on an integral cast-steel underframe, carried on two four-wheel, swivel-type trucks. The centrally located operator's cab has its floor and roof raised above the levels of the main floor and hood roofs, respectively, and is built to a width exceeding that of the equipment hoods and supporting underframe, which, with suitably arranged windows, provides for visibility both over and along the sides of the equipment hoods. The operator's cab and equipment hoods are streamlined to a degree sufficient to avoid the box car appearance frequently found in units of this type. A diesel power plant with its auxiliary equipment is housed in each of the equipment hoods.

The underframe incorporates storage reservoirs for fuel and lubricating oil, mounting rails for the engines and generators, air ducts for traction-motor ventilation, truck center plates, cab side bearings and bolsters, draft-gear housings, four sand boxes and push-pole pockets.

The trucks have integral cast-steel frames, side equalization with semi-elliptic springs, clasp brakes, carbon-steel axles. A.A.R. boxes and brasses with 8-in. by 14-in. journals, and rolled-steel wheels. All wearing surfaces on the truck frame and underframe are protected with hardened-steel plates and holes for brake-hanger pins are bushed. Truck and underframe center plates are likewise bushed with hardened-steel bushings.

Driving journals are oil lubricated and hub liners and center plates are arranged for Alemite lubrication. Pedestal ways are oil lubricated from oil-and-waste pockets on the box.

The unit is equipped with A.A.R. type 6-in. by 8-in. shank swivel-butt couplers and Miner friction draft gear, Peacock type hand brake, Graham-White sanders, Pyle-National headlights and number boxes, and air-operated window wipers and bell.

Diesel engines.

The diesel engines are rated 800 H.P. each at 900 r.p.m. They are of the solid-injection, 12-cylinder, V-type, operating on the four-stroke cycle. They have integral cast-steel crankcases which are machined for cylinder liners and heads, main bearings, cam-shaft bearings, gear case and fuel pump mountings and inspection cover plates. All engine auxiliaries, such as main fuel pump, water pumps, lubricating-oil pressure and scavenging pumps, governor oil pump and cam shafts, are driven by gears at the front end of the crank case.

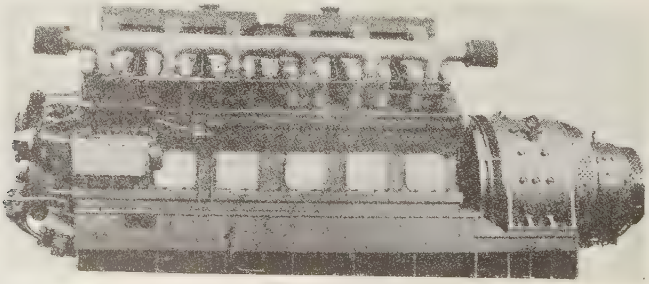


Fig. 2. — One of the 12-cylinder, V-type, 800-H.P. diesel engines.

Removable liners of nickel cast iron are fitted in the crank case. Each cylinder is provided with an individual cylinder head, cast from aluminum alloy with steel valve seats for dual inlet and exhaust valves. The pistons are made from an aluminum alloy and machined for pressure and oil-control rings.

The fuel injection system consists essentially of a motor-driven gear pump, taking fuel oil from the main reservoir and delivering it through strainers to the main fuel-pump headers, at a pressure of approximately 30 lb. per sq. in. A main fuel-pump assembly, consisting of six units, is mounted on each side of the crank case serving the six adjacent cylinders.

Electrical transmission.

Each power plant has a single-bearing main generator which converts the mechanical power at the engine shaft to electrical energy for use by the traction motors.

An auxiliary generator is mounted on each of the main-generator bearing brackets, with its armature on an extension of the main generator shaft. A fan, mounted on each engine flywheel, draws air through the main and auxiliary generators, cooling both machines. The main generators are used as motors for cranking the Diesel engines during starting.

Four traction motors, utilizing the electrical power furnished by the main generators supply the propelling force for the locomotive. One motor is geared to each of the driving axles through a pinion on the motor shaft and a gear on the driving axle. The gearing is a spur type, machined from steel forgings and heat treated. The traction motors are of the direct-current series type, force ventilated and equipped with roller-type armature bearings and split-sleeve type axle bearings.

Control and brake equipment.

The locomotive is equipped with Westinghouse standard dual control, developed especially for diesel-electric locomotives to provide maximum flexibility with one-man operation. Pedestal-type controllers and brake-valve operators are located at each of the operating stations. Their shafts extend through the cab floor, and are inter-connected with sprocket gears and chains. A standard K 14 brake valve, minus the handles, is located directly below one of the brake-valve operating pedestals with their corresponding shafts connected together. Westinghouse modified schedule 14-EL air-brake equipment with quick application and release feature is used. Two single-stage, two-cylinder, water-cooled air compressors, each having 120

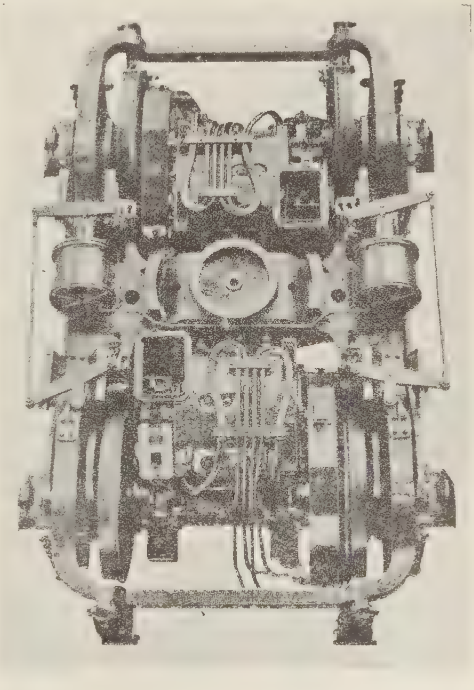


Fig. 3. — A view of the truck showing the arrangement of the motors and brake equipment.

cu. ft. displacement, driven by a 115-volt, direct-current, series motor, furnishes air for the operation of the brakes and electro-pneumatic control equipment. Both compressors and motors are equipped with ball bearings.

Two 14-in. by 10-in brake cylinders are mounted on each truck, one cylinder being connected to the brake rigging on each side of the truck. An auxiliary hand brake is connected to one truck for holding the light locomotive at standstill.

Engine loading is controlled over the range of generator voltage and current by the Westinghouse torque-control system. Meter and gage panels, located at each operator's station, include meters for indicating main generator amperes, battery amperes, engine jacket water and oil temperatures, and air-brake gages.

The initial starting of each engine is controlled from positions adjacent to the respective engines. Starting and stopping of each engine may be controlled from the operator's station by electro-pneumatic mechanisms after main-reservoir air pressure has been pumped up. The starting battery consists of a 50-cell, Exide Ironclad battery having 15 plates per cell.

The control is arranged for the operation of all traction motors from either power plant, with the second power plant non-operative.

Foot-operated push buttons are located, one at each operator's station, for controlling weight-transfer compensating switches to permit working all drivers at maximum adhesion when the greatest starting tractive effort is required.

General characteristics:

Starting tractive force at 30 % adhesion	80 000 lb.
Tractive force at continuous rating of traction motors	32 000 lb.
Speed at continuous rating of traction motors	15.6 m.p.h.
Maximum operating speed	50 m.p.h.
Minimum radius of curvature:	
Locomotive alone	85 ft.
Locomotive with load	175 ft.
Length inside coupler knuckles	52 ft. 11 in.
Length over operator's cab and hoods	49 ft. 8 in.
Overall width	10 ft. 2 in.
Heights from rail:	
Overall (at operator's cab)	14 ft. 1 in.
Over hoods (at coupler ends)	11 ft. 8 in.
Truck center distance	27 ft. 0 in.
Truck wheel base	8 ft. 6 in.
Wheel diameter	44 in.
Capacity of fuel oil reservoir	1 000 gallons.
Capacity of sand boxes	5 000 —
Capacity of jacket water system per engine	210 —
Capacity of lubricating oil reservoirs per engine	85 —

[656. 257 (.73) & 656. 259 (.73)]

Remote control replaces a mechanical interlocking on the Louisville and Nashville.

(From *Railway Signaling.*)

At AX, the north end of the freight yards near Birmingham, Ala., the Louisville & Nashville has replaced a 19-lever manually-operated mechanical interlocking with an arrangement of three spring switches, a power-operated switch, and power signals, controlled by a C. T. C. type machine in an interlocking tower 1 1/4 miles away.

The AX track layout includes a facing-point crossover, switches B and W, between the two main tracks, switch A leading to the southbound freight yards and switch C leading from the northbound yard to the northward main track. All of the southbound freight trains leave the main line at AX using the facing-point crossover and single switch A for the yard lead. Likewise all northbound freight trains use the northward single-track lead, which extends around the southward yard, and enter the northward main track at single switch C at AX. All passenger trains are operated through AX on the two main tracks, right-hand running.

Only one power switch required.

The operation of trains, as explained, established the fact that a selection of routes for facing-point switch operation was necessary only for switch W, the north switch of the crossover. Therefore, it was evident that the two single switches to the yard leads and the south end of the crossover could be operated by spring mechanisms, the north end of the crossover being equipped with a power switch machine so that the route for southbound trains could be selected for either the through main-line route or to divert trains over the crossover and through the single switch, leading to the yard. In making the crossover movement, a train would trail through the spring switch B at the south end of the crossover. The yard lead switch A is normally lined for the turnout to the yard, which means that all northbound trains making a through movement on the northward main track would trail through this spring switch. On the other hand, switch C for the lead from the northward yard is normally set for the main line, so that northbound freight trains pulling out of the yard trail through the spring switch.

Thus, with the layout of three spring switches and one power switch, all of the train movements made regularly through this junction are made the same

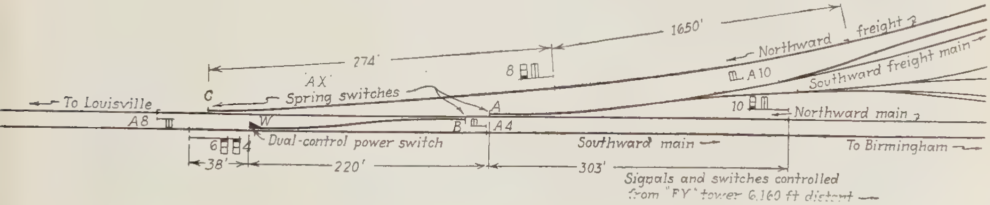


Fig. 1. — Track and signal plan of remote control interlocking at « AX ».

as when the manually-operated plant was in service. The traffic through this layout daily includes five passenger trains each way and 10 to 12 freight trains each way.

As a necessary part of the changeover, power-operated semaphore signals were installed to replace the mechanically-operated high signals, including signals 4, 6, 10 and 8, these signals, together with the power switch machine, being controlled by a two-lever C.T.C. type desk machine located on the operator's table in the interlocking tower at FY, 1 1/4 miles south of the AX layout.

The back-up dwarf signals A4 and A8 are inoperative, being fixed in the stop position. When it is necessary to make switching moves against the normal direction of traffic, authority is given by the dispatcher through the operator at FY. Likewise, if it should become necessary in an emergency to run through-trains against the normal direction of traffic, authority to pass these fixed dwarfs, together with instructions as to operation of the switches, would be given by train order. For a northbound through movement on the normally southward track, the operator at FY would see that switch W is properly lined, but a train making such a move would be required to stop and check the position of the switch and if it were not properly set, it would be thrown manually by means of the dual-control lever. For a southbound through movement on the normally northward track, a train would be required to stop and check the position of the switches, and, of course, throw switch A to line up for the through movement.

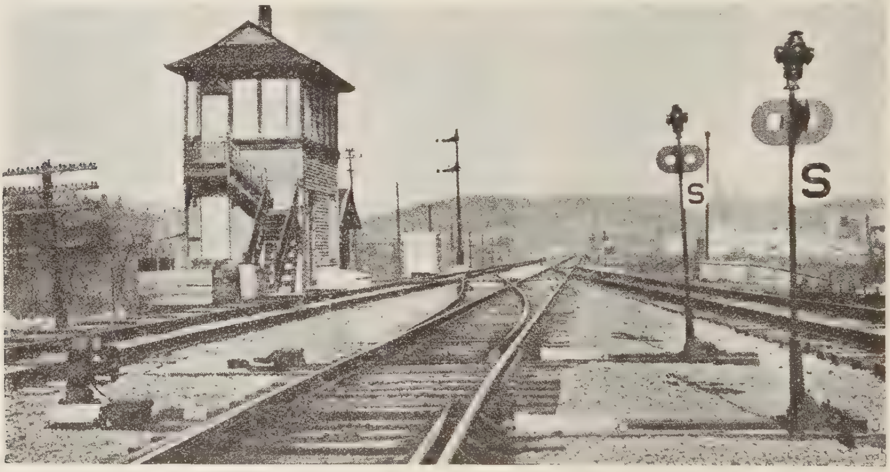


Fig. 2. — View looking north showing spring switches A and B in the foreground—Note spring-switch markers.

The control system.

The control machine in the tower at FY includes on the face of the cabinet, an illuminated track and signal diagram, below which are two revolving button-type levers, in a vertical row. These levers stand normally on center with the arrow in the face of the button pointing upward, all signals being normally in the stop position. The top lever is for the control of signals 8 and 10; when the lever is turned 90° to the left, signal 8 clears, and, when the lever is turned 90° to the right, signal 10 clears. The lower lever controls the operation of the power switch W as well as signals 4 and 6. If the switch is in the normal position, that is, lined for the through train movement, turning the lever 90° to the left will clear signal 4. In case the switch is in the reverse position, turning the lever from the center position to the left will cause the switch to be thrown to normal, after which signal 4 will clear. In a similar manner, turning the lever to the right from center causes the switch to move to the reverse position and clears the lower arm, signal 6, to direct train movements over the crossover. Thus the control of the entire layout, involving four swithches and four signals, is controlled by two levers.

On the illuminated track and signal diagram above the levers, one normally extinguished red lamp in each of the three approach sections and each of the three detector sections inside the home signal limits, are lighted to indicate when each respective section is occupied by a train. A bell rings at the same time that each of the approach sections is occupied and the ringing of the bell can be stopped when the operator pushes the button below the levers. A red lamp in the detector section including the power switch is used also to indicate the operation of the switch. When the switch lever is turned, this lamp flashes and the bell gives one stroke when the switch is unlocked, und then when the switch has completed its movement and is locked in the opposite position, the lamp flashes and the bell gives another stroke.

Control and indications circuits.

The control and indication circuits are based on the unit wire system. For the control of the power switch as well as signals 4 and 6, a circuit of one wire in connection with common extends from the lever at FY to a polar relay at AX. When the lever is on center the circuit is open and the relay released. By means of a split-battery feed, the polar contacts of the relay are thrown one way or the other, depending on whether the lever is thrown to the left or to the right, and the operation of the switch to the normal or to the renverse position is controlled by the position of the polar contacts. The control of the signals 4 and 6 extends through neutral contacts of the polar relay and through contacts on the switch machine, one signal or the other being cleared, depending on the position of the switch, but neither signal clears if the lever is on center because the neutral contacts of the relay are open.

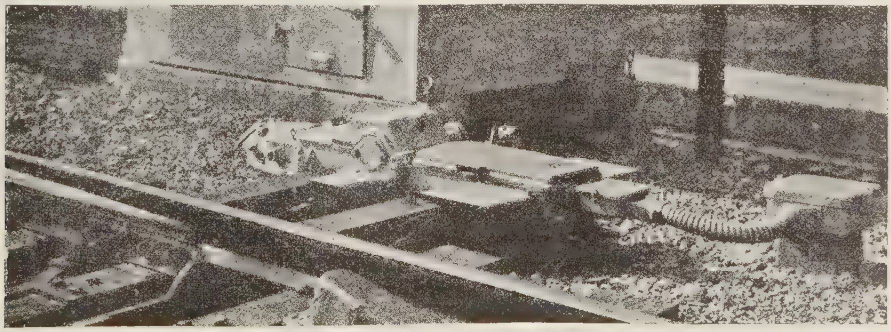


Fig. 3. — Power-operated switch machine with sheet-metal house nearby.

Likewise signals 8 and 10 are controlled by a circuit including one wire and common extending from the lever to a polar relay at AX. When the lever is on center the line circuit is open, the relay is released, and both signals indicate *stop*. When the lever is turned to the left the relay is energized with the polar contacts closed to complete the circuit to clear signal 8, and when turned to the right to clear signal 10.

The local controls of the switch and the signals are interconnected and extended through the track relays to provide proper interlocking protection. Approach locking, accomplished automatically by time-element relays, effects a delay of 2 minutes and 40 seconds between changes in a line-up in case a train is occupying any of the approach track circuits involved.

The circuits for bringing in the indications, as to operation of the switch and occupancy of the approach and detector sections, are combined so as to require a minimum of line wires. The circuit for the indication of the operation of the switch is taken through contacts of the switch repeater relay and then extended over the same wire and common as used for the control of the switch.

Furthermore, this line wire and common are also used to bring the indication as to the occupancy of the detector track circuit, including the power switch. A combination circuit, involving one wire and common, using an oscillating relay, is used to bring in the indications as to occupancy of the approach sections on the southward main and northward freight tracks. One line wire and common are used for each of the two remaining detector sections between signals 8 and 10 on the northward main track and for the southward main-line approach. Thus a total of six wires and a common wire are required on the line from the AX layout to the tower, a distance of 6 160 ft.

Sheet metal house at AX.

At AX, a welded sheet-metal house 6 ft. by 8 ft. in size is utilized to house the instruments and battery. The instrument rack, on the west wall, consists of 1 1/2 in. by 8 in. pine boards bolted to the angle-iron upright, with a 2-in. clearance behind the boards for wiring space. The relays and other instruments are of the wall-type mounting with spring suspension on all the relays. This house was wired complete with all instruments in place, at the Louisville & Nashville signal shop in Louisville.

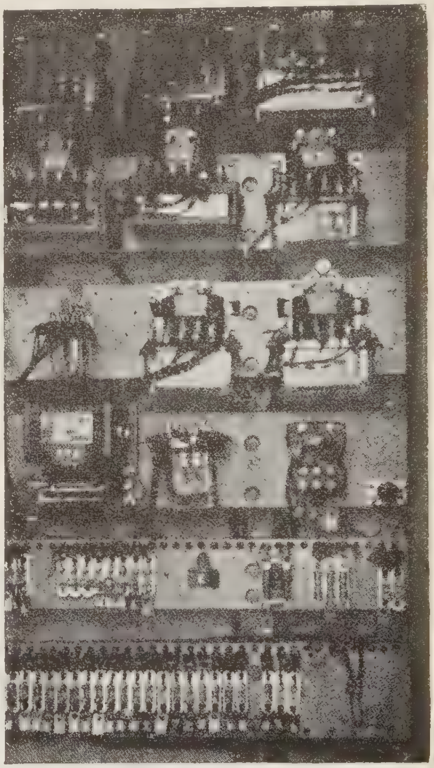


Fig. 4. — The instruments are mounted on racks in the sheet-metal house.

The battery for the operation of the switch and signals consists of 10 Exide DMG0-9 cells, this battery being split to be used also for control and indication circuits, and is on floating charge through two type-BT rectifiers. At the control station, a set of 10 DMG0-7 cells is used to feed control and indication circuits on a split-battery arrangement. Each of the two main-line distant signals, No. 2 and No. 12, are operated by a set of 16 cells of 500-a. h. Waterbury primary battery. Likewise, each track circuit in the entire installation is fed by three cells of 500-a.h. Waterbury primary battery.

Switch operating mechanisms.

The power switch machine is of the G.R.S. model-5D type with a dual-controller so that the switch can be thrown manually if necessary. The 20 volt-D.C. motor will operate the switch in 18 seconds. Tie plates 1 in. by 7 in., together with Stiles adjustable rail braces, are used on three ties in this switch layout.

Each of the three spring-operated switches is equipped with a Pettibone-Mulliken mechanical-switchman type spring-switch mechanism. As a part of the new improvements, new switch ties and Weir No. 27 switch stands were installed at these three switches. Each spring switch is identified by a marker « S » in a black letter on a white background, on a sheet metal disc attached to the shaft of the stand below the regular switch target, as shown in the illustration.

The rail throughout this territory is 100 lb., and the turnouts are No. 12, each equipped with 22-ft. switch points. For the spring-switch layouts, each point is reinforced with two steel bars, one of which is 1 1/4-in. and one 3/8-in. thick. These bars are held in place by body-bound bolts.

The rules specify that northbound through trains on the main line must reduce speed to 30 m.p.h. when trailing through spring-switch A. The same rule applies for the freight trains when trailing through spring-switches B or C.

A switch circuit controller is connected to the normally-closed point of each switch, the adjustment for opening the circuits to hold the signals at stop being set at 3/16 in. for the facing-point switch and 1/4 in. for the trailing-point switches.

No trunking is used on this installation, all wire runs to the signals and switches being in underground Okonite parkway cable made up with a lead sheath steel tape, jute, etc.

For track connections single No. 9 solid conductor Okosheath cable, without lead or steel tape, is used. Each bootleg outlet consists of a riser of creosoted pine 3 7/8 in. square and 18 in. long with a round 2-in. hole running through the center, and a malleable-iron cover fitting down over the top of this riser. As shown in the illustration, a clamp arrangement forms a part of the outside top of the cover. The two stranded connections extending to the plug in the rail fit under the clamp, and the end of the No. 9 cable wire is brought up through a 3/8-in. hole in the cover and connected under a washer on the 1/2-in. galvanized bolt. After the cable is installed, a 3/8-in. by 5-in. galvanized carriage bolt is passed through the cover and the top, horizontally, to hold the cover on to the riser. Each of the two connections between the outlet and the rail consists of one annealed copper conductor 77 mils. in diameter and six galvanised steel wires 77 mils. in diameter. As the bootleg is usually located in the second tie space from the joint, the connections are about 34 in. long. The parkway bootleg outlets, as described, were designed by the signal department of the Louisville & Nashville and were manufactured by the Peerless Manufacturing Company.

At the switch machine, as well as at each switch circuit controller, the underground cable is terminated in a cast-iron junction box set on a concrete foundation, single-conductor wires being extended from the box through flexible metal conduit to the switch machine or circuit controller. This method is used to allow for the vibration of the track. As a part of the new installation, the rail joints were bonded with Ohio Brass Co. OB alloy welded bonds.

This changeover from the mechanical interlocking to the remote control was engineered and installed by the signal forces of the Louisville & Nashville, the signaling equipment including the control machine, power switch relays, rectifiers, etc., being furnished by the General Railway Signal Company.

[625 14 (01]

Track laying for high speeds.

Mr. Baticle, *Director of the Railway Technical Operating Inspectorate of the French Ministry of Public Works, has sent us the following note in connection with the article, by Professor* Corini, *we published under the above title in the April 1936* Bulletin.

« In an article published in the January 1936 Bulletin and entitled « Railway track construction for high speeds », Professor Corini refers to my own study on « La longueur des voies, facteur de sécurité des voies ferrées » (The influence of the length of rails on the stability of the track), published in the *Génie Civil* of the 2nd April 1932.

» Professor Corini criticises the hypothesis I adopted, together with many other authors, of considering the ballast as an elastic medium.

» I feel that this criticism is ill founded as the phenonemon is one of Eulerian lateral bending. The stability, as regards shape, of a funicular system under a force normal to it is due to the impossibility of any *infinitely small* transverse deflection taking place in it. When sufficiently small deflections are impressed on the track the reactions increase within the amplitude of the displacements. This fact has been brought out very clearly by Mr. Blondel [see « La résistance de la voie aux oscillations de lacet des véhicules » (Resistance of the track to the oscillations due to the vehicles hunting), *Revue Générale des chemins de fer*, December 1932]. Coulomb's friction between two bodies in contact is only set up when there is effective rupture over the whole surface in contact. The deformation becomes permanent at this moment. The law of the deformation in terms of the slipping force before rupture doubtless is not a lineal one but it is quite reasonable to retain only the first term of the equation as the theory of lateral flexion only allows for infinitely small deflections.

» I also think that, from the sole *point of view of the bending itself*, i. e. ignoring the transverse thrusts or shocks, it is more prudent to consider the elastic reactions rather than the frictional ones.

» As I have just pointed out, when the latter occurs, permanent deformation, if not of the rail certainly of some of the parts which ensure its lateral stability, takes place as friction is a phenonemon irreversible by its nature.

» This does not mean that the resistance to transverse movement due to friction is not to be considered when dealing with lateral stability of the track as a whole. I will return to this point later on.

» I feel I must point out that Mr. Corini is taking rather a risk in taking as the moment of inertia the product $2\ S \left(\frac{s}{1}\right)^2$, s being the gauge. This supposes the track to be a triangulated and geometrically indeformable system, an assumption which does not appear to be true.

» Be this as it may, and leaving aside questions of doctrine and pure theory, Mr. Corini, as I endeavoured to do, has brought out the importance of the transverse resistance of the track and *the value of increasing it* (1) as regards either doing away with rail joints or increasing the safety at high speeds. In my opinion, this point of view has been neglected too much, in both the relaying and maintenance regulations (2), and we must rejoice if Mr. Corini's article and those to which he refers induce the permanent way engineers to consider a revision of the regulations. »

E. BATICLE.

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(1) Apart from anchoring the sleepers to posts, as suggested by Mr. Corini, this resistance can be improved by ramming the ballast between the sleepers so that the sleepers are wedged into position. I have on occasion suggested this method be used, but without success. The sleepers could also be connected along their centres by a sort of keel.

(2) In America the track is hardly touched once laid and there appear to be few accidents through transverse deformations of the track. There are more such accidents in Continental Europe and the track might with advantage be laid more solidly from the beginning.

[621. 138 (.42) & 625. 154 (.42)]

RECENT DEVELOPMENTS
IN RAILWAY PRACTICE.

Locomotive turning by power from the vacuum or compressed air brake systems.

During recent years one of the problems presented by the increased weight and wheelbase of the modern locomotive has been to turn such locomotives at terminal points, and at locomotive running sheds.

The improvements in running shed facilities to reduce the time taken to prepare engines drew attention to the time taken to turn locomotives by hand, as apart from the actual turning time, there was the added time to get the engine into the right position. There are objections to turning tables by electric power, and a simple solution was required, preferably taking its power from the locomotive.

The purpose of this brief article, therefore, is to give a short description of an entirely original drive of this kind patended in 1934 by Messrs. Cowans, Sheldon & Company, of Carlisle, the motive power of which is supplied by the vacuum or Westinghouse brake system of the locomotive to be turned.

Sir Nigel Gresley, C.B.E., the Chief Mechanical Engineer of the London and North Eastern Railway, allowed the first equipment to be fitted to the turntable at King's Cross Locomotive Depot.

The tests were very satisfactory, but as is the case with many original designs, practice often suggests minor improvements, and today a similar tractor, unchanged in its leading features, but embodying the refinements considered desirable after nearly three years successful service, has replaced the earlier model.

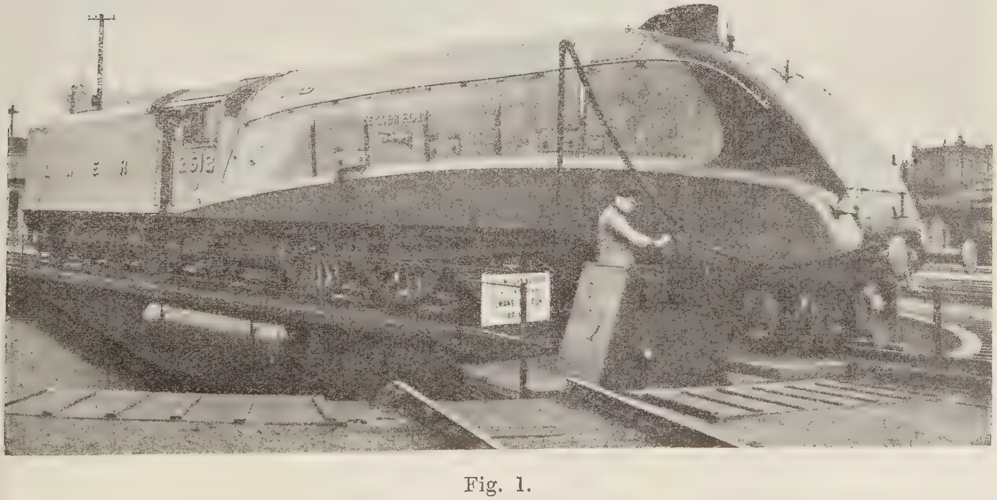

Fig. 1.

The photograph reproduced as figure 1 shows one of the new A. 4 type « Silver Jubilee » engines of the L.N.E.R. being turned by one of these latest tractors fitted to a table of the balanced type.

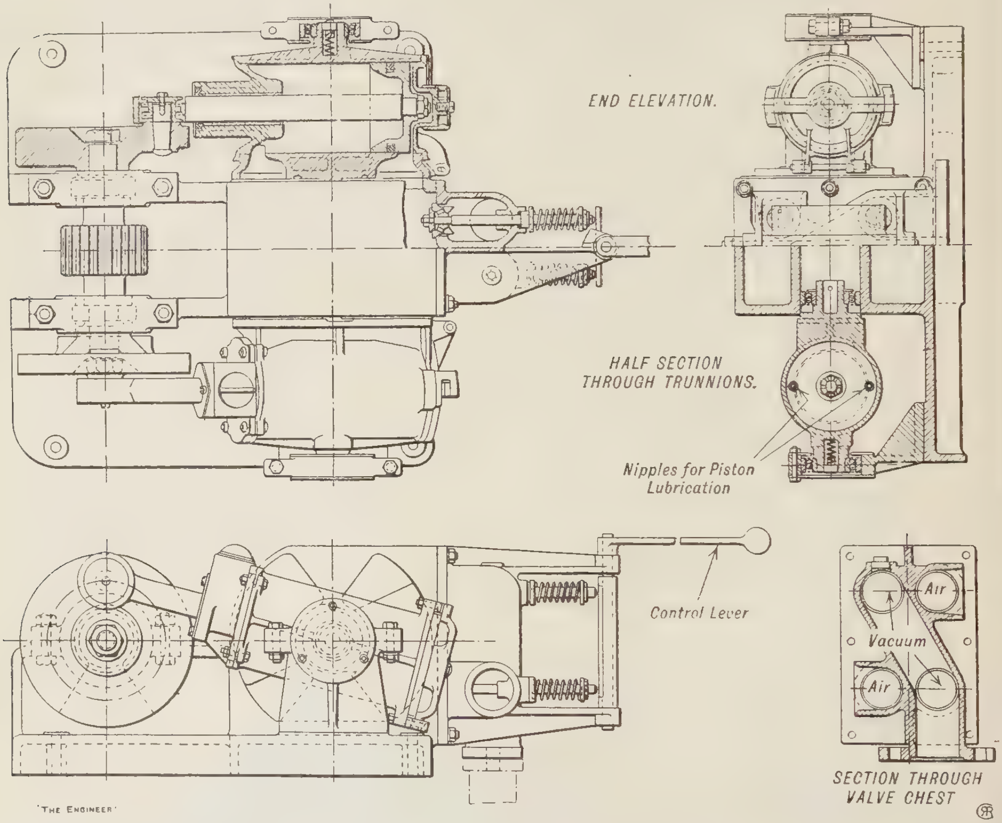
END ELEVATION.
HALF SECTION THROUGH TRUNNIONS.
Nipples for Piston Lubrication
Control Lever
Air
Vacuum
Air
SECTION THROUGH VALVE CHEST
'The Engineer'
®

Fig. 2. — Actuating motor of turning gear.

The motor. — The arrangement of the motor is shown in elevation, section and plan in figure 2 (reproduced by courtesy of *The Engineer*). Consisting of two double-acting oscillating cylinders, 4 1/2″ bore by 6″ stroke, fitted with pistons of a light alloy and mounted horizontally on either side of a centrally disposed valve chest, the motor transmits its power from each cylinder to a common crankshaft directly through the piston rods which are coupled to it, no crosshead being necessary.

The engine is controlled and reversed by a lever operating four valves of the poppet type, which enables the top and bottom chambers of the centre casting, against which the cylinders work, to be open alternately to air at atmospheric pressure and vacuum, or air pressure, as the case may be. With this system no brake is necessary.

The gearing and drive. — The power is transmitted from the crankshaft to the race wheel through two reductions of spur gearing, all of which have machine-cut teeth. This is illustrated in figure 3 (reproduced by courtesy of *The Railway Gazette*).

The intermediate shaft is carried in ball bearings attached to the steel frame of the tractor which, in the case of the balanced type of turntable, is connected to one of the beams by a hinged connection. The latter permits the table to move freely and at the same time enables

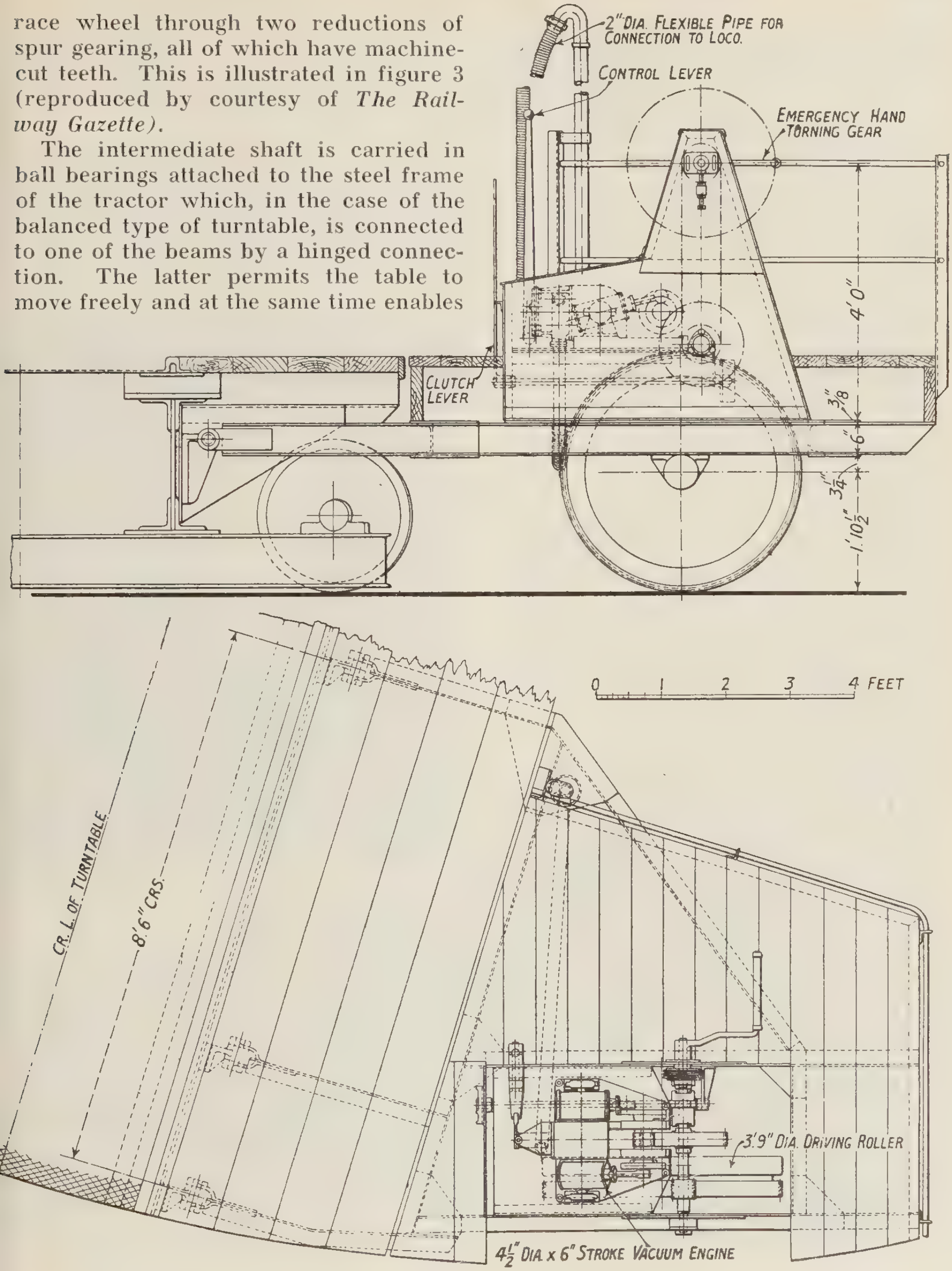

Fig. 3. — Details of tractor as applied to balanced turntable.

the race wheel to receive the correct adhesion required to drive the table.

Control. — The tractor is started, stopped, and operated in either direction by the movement of a single lever, thus reducing the operation to one of ideal simplicity, involving no risk either to the operator or to the machine. Figure 4 illustrates the control lever and housing of the tractor.

In order to enable the table to be turned by power when dealing with cold engines or when it is necessary to adjust the empty table to suit the angle of the roads, as is the case at King's Cross, vacuum accumulators are provided of sufficient capacity to suit the circumstances, and one of these can be seen in the photograph (fig. 1).

In addition to the above, means are provided for operating by hand power under emergency conditions, the change from the power to the hand motion being effected by the movement of the clutch lever shown on figure 4.

The advantage of turning in this way is shown by the following times :

Hand turning. . . .	2 1/2 min.
Power turning . . .	1 min.
Reduction in time . .	1 1/2 min.

It will be appreciated that the motor could be connected to the train pipe on the engine near the cab, and that the vacuum or air pressure could be used to withdraw the locking bolts, which would obviate the enginemen having to go to the end of the table and would save further time in cases where it is essential to reduce to a minimum the time taken. This, however, involves a certain complication, and in the table in question it was considered that connecting up to the train pipe at the end of the engine or tender formed a convenient and simple method of providing the power required.

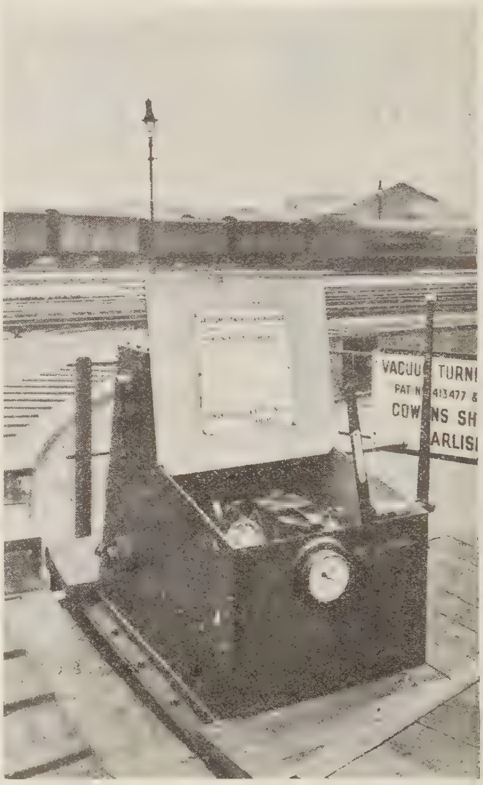

Fig. 4. — Control lever and housing of the tractor.

MISCELLANEOUS INFORMATION.

[621. 132.3 (.73)]

1. — Class K4s Pacific type streamlined locomotive, Pennsylvania Railroad.

(*Railway Mechanical Engineer.*)

The Pennsylvania has recently turned out from the Altoona shops a Class K4s *Pacific* type locomotive and tender which has been completely streamlined by cowling over the boiler and skirting which extends down from the running board and around the front of the locomotive. The cab is faired into the lines of the locomotive, and the tender has been made to continue the lines of the locomotive by curved sides above the top of the tender, which conform to the sides of the cab roof. The top of the tender is not enclosed. The bottom of the skirting and tender form an unbroken line with the bottom of the coach sides when the locomotive is coupled to a train.

An outer diaphragm of heavy sheet rubber closes the space between the front of the tender and the rear of the cab, which is entered by side doors at the gangway behind the enginemen's seats. This diaphragm, which is put up under tension, provides a smooth, continuous surface between the engine and tender while standing on straight track, and stretches as much as is necessary to conform to the relative movement between the engine and tender on curves.

The body color is a gun metal tone against which the striping stands out sharply. The letters and the stripes on the tender and around the cab windows are in gold. The stripes on the engine are stainless steel, as

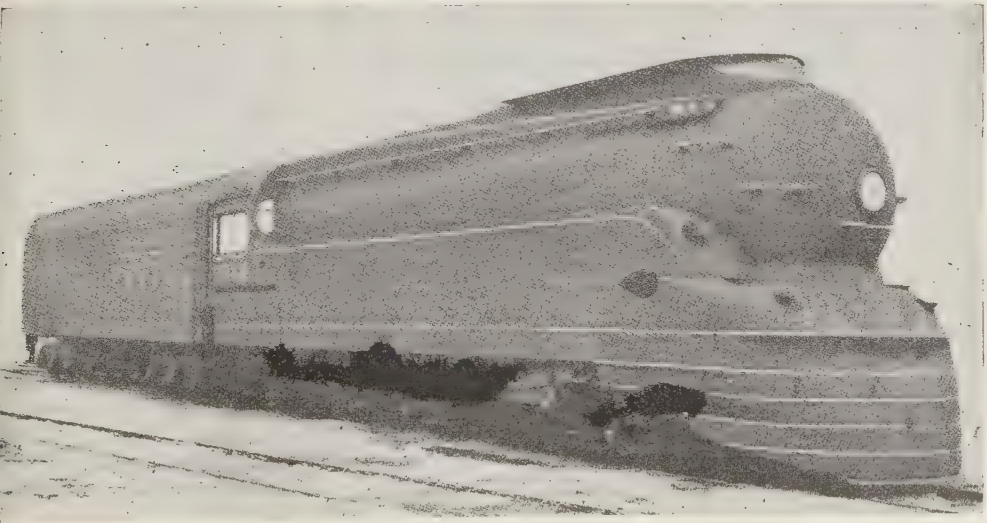

Fig. 1.

are also the handrails on the sides and front end and the winged keystone emblem on the cowling in front of the stack.

By the separation between the front end of the boiler and the skirting is front of the pilot and around the cylinders the characteristic appearance of the steam locomotive has been retained. Aside from its pleasing appearance this separation is said to reduce the tendency to develop low-pressure pockets along the sides of the boiler at the front of the cab, which is characteristic of the so-called shovel-nose form. A further division of the air stream toward the same end is effected by a horizontal plane projecting around the front end of the locomotive at approximately front deck-plate height.

The smoke-lifting device consists of the stack cowling, enclosing a space of considerable width at the sides of and behind the stack, which is closed at the top by a horizontal plane flush with the top of the stack and extending somewhat beyond the cowling at the front and sides. Along each side of the boiler, starting with the enclosure for the classification lights at the front is a plane, the lateral elements of which are horizontal, which slopes upward toward the rear and blends into the contour of the cab roof. The space between each of these planes and the under side of the projecting horizontal plane is thus narrowed toward the rear, tending to produce a slight increase in air pressure and velocity at the rear end of the horizontal plane. This is said to remove all tendency for smoke to trail along the top of the boiler and the lateral component of the increased pressure in the air stream between the two planes is also a factor in reducing low-pressure spots along the side of the boiler toward the front of the cab.

The front end of the locomotive is completely equipped with a coupler and both brake and signal hose connections. When not in use the coupler is swung back horizontally and the hose connections are dropped into place behind the contour of the skirting which is closed by a panel permanently attached to the locomotive and which moves up and back within the skirting when opened.

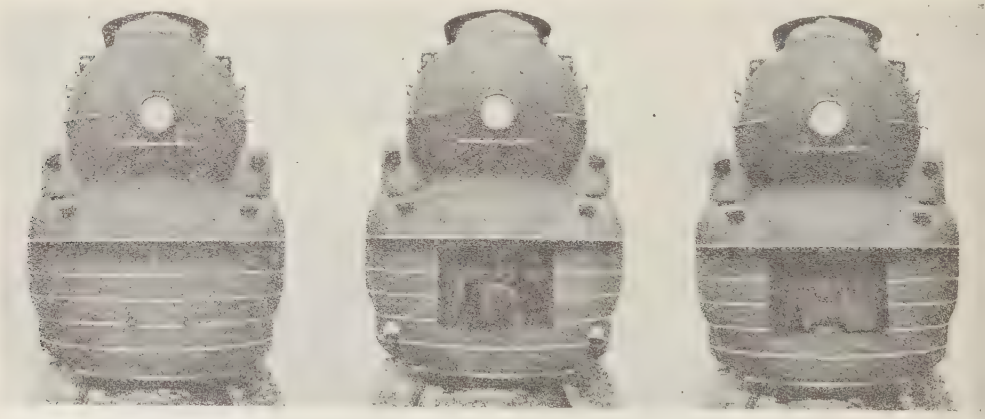

Fig. 2. — The brake and signal hose connections and the coupler are always ready for service. The panel rolls back behind the shrouding.

The boiler cowling and cab are fabricated of sheet steel. The skirts below the running boards are of aluminium sheets. A long panel of each skirt is arranged to be completely removed by removing a few bolts when access to the rods and motion work is required in the enginehouse or shop. Doors have been provided at points where access for lubrication is not otherwise available. The smokebox and smokebox front have been lagged to protect the cowling from the heat. Openings in the cowling are provided over the whistle and pops, the location of which has not been changed. The sand box, however, has been moved forward immediately behind the stack. The bell is mounted on the engine frame under the cowling at the front of the locomotive.

The tender has 18 000 gallon capacity. The water tank is provided with two longitudinal filling holes, one in each side. The panels in the curved extensions of the tender sides opposite these openings are arranged so they may be unlatched and rolled laterally toward the center of the tank to clear the filling holes.

The locomotive as altered has a weight in working order of 337 850 lb. and the weight of the tender loaded is 289 700 lb. The overall length is 95 ft.

The design of the streamlining was developed by the railroad's engineering department in co-operation with Raymond Loewy, New York, an authority on streamlining and a member of the road's technical advisory staff. In working out the final design tests were carried on over a period of months in the wind tunnel of the New York University aerodynamic laboratory. Instead of the usual type of wood or metal models, clay models were used for the first time in these experiments. They demonstrated their superiority over the other materials because of the readiness with which shapes could be altered immediately upon observing the results of each test. Observations of air flow were made by the use of both silk threads and smoke bombs.

The comparative wind-resistance tests were made with models of the locomotive, tender and one coach. Under these conditions at wind-tunnel speeds of 100 m.p.h. the air resistance was reduced from 896 HP. with a conventional locomotive to 600 HP. with the streamliner.

[**621**. 43 (.43)]

2. — German State Railways' 1 400-H. P. diesel locomotive, with hydraulic transmission.

(Le Génie Civil.)

The various methods of transmitting the energy from the crankshaft to the driving axles are the result of the difficulty of making the characteristics of the diesel engine agree with traction requirements. Many designs of electric transmissions have been introduced, most of which have been described in the *Génie Civil*, as have the compressed-air, the direct, the Zarlatti compressed-air, using a mixture of compressed air and water vapour (1) drives.

The hydraulic transmission, so far only fitted to railcars, has been used for the first time on a 1 400-H.P. locomotive exhibited by the Reichsbahn at the Railway Centenary Exhibition at Nuremberg in July 1935. The following description is based on data published by Messrs. Fuchs and Grasse in the *Zeitschrift des Vereines deutscher Ingenieure* of the 12th October 1935.

This locomotive was built by the Krauss-Maffei Company, to haul 500-ton goods trains up 1 in 100 gradients at 30 km. (18.6 miles) an hour, or passenger trains at 100 km. (62 miles) an hour. The axle load had no to exceed 15 tons.

The 2-6-2 type engine is illustrated in elevation in figures 1 and 2. Driving compartments are provided at each end, the locomotive being reversible. The length over buffers is 14.40 m. (47 ft. 2 in.); the weight in work-

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(1) The diesel locomotive with compressed-air drive was described in the *Génie Civil* of the 24th May 1930, p. 497, the direct-drive locomotive in the 7th July 1934, p. 13, and the Zarlatti locomotive in the 29th September and 5th October 1934 numbers, pp. 277 and 306.

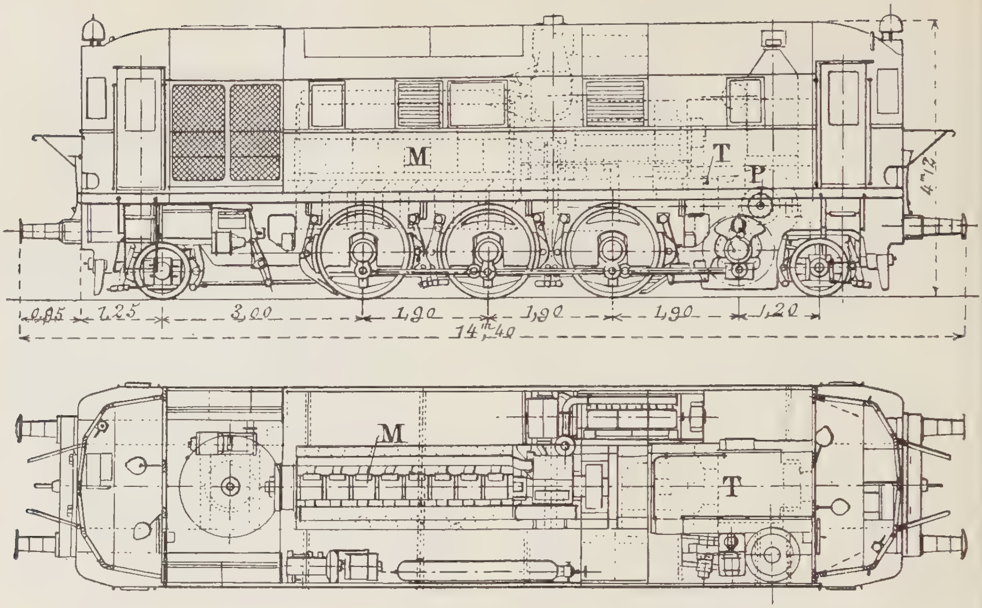

Fig. 1. — Elevation and plan of the 1 400-H.P. diesel-hydraulic locomotive.

ing order is 75 tons, and the adhesive weight 45 tons.

The power unit is a M. A. N. diesel with 8 cylinders in line running at 700 r. p. m. developing 920-H.P., or 1 400-H.P. when worked with the Büchi supercharger (2).

This engine drives, through the hydraulic transmission T and the intermediate shaft P, the jack shaft Q to the ends of which are keyed two cranks in line with the wheels, which drive the wheels through coupling rods.

The Voith-Föttinger hydraulic transmission is illustrated diagrammatically in figure 3. The coupling A between the hydraulic gear and the engine is intended to absorb any torsional vibrations. The main shaft of the hydraulic drive carries, in line with the gears B, two concentric sleeves (the outer of which has teeth cut on it). When the shaft *a* is turning at 700 r. p. m., the outer sleeve is driven at 1 770 r. p. m.; this speed is transmitted to the casing C of the hydraulic coupling and to that of the hydraulic coupling D, connected together by the tie bars *b* cast integrally with them to the sleeve *c*, and to the blades *d* of the primary rotor of the torque converter E.

The gear is designed to run at this higher speed in order to make it more compact. The difference between a coupling and a torque converter is that the former has two sets of blades, one of which acts as the driving pump and the other as the driven turbine, whereas the torque converter has three, two as in the coupling and a third the blades of which are stationary and act as guides. In this design the stationary guide blades *e* of the converter are built into the casing which therefore remains stationary, whereas in the couplings as the driving and driven couples are always equal (neglecting friction losses) the casing revolves with one or other set of blades to reduce the friction in the driving fluid, in this case with the set of blades *f*, acting as the pump, to which it communicates it rotary motion.

The three constituent members of the hydraulic gear are brought into action in turn

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(2) Supercharging by turbo-compressor driven by the exhaust gases, Büchi system, was described in the *Génie Civil*, 5th and 12th January 1935, pp. 12 and 33.

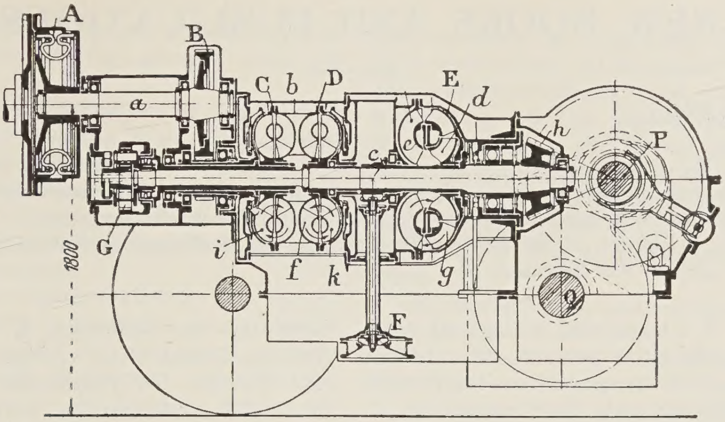

Fig. 2. — Diagrammatic section of the hydraulic transmission, Voith-Föttinger system.

by filling them by means of the centrifugal pump F submerged in the oil tank and driven by a bevel gear off the sleeve *c*. The oil is delivered partly to a cooler whence it returns to the tank and partly to a distributor which delivers it to the gear selected, the oil in which is constantly renewed.

When starting and up to 48 km. (30 miles) an hour, the converter E remains in action; the blades *g*, keyed to the main shaft, directly drive the bevel gear *h*. Between 48 and 70 km. (30 and 43.5 miles) an hour the liquid is sent to the coupling C, the blades of which, acting as a turbine, are keyed to the inner sleeve which passes under the gears B to the epicyclic reduction gear G. This gear G drives the main shaft and the pinion *h* at the speed of the blades *i* reduced in the ratio of 1.43 to 1. From 70 to 100 km. (43.5 to 62 miles) an hour, the maximum speed, the liquid is sent to the coupling D, the blades *k* of which act as a turbine, are keyed to the main shaft and drive the pinion *h* at their own speed. The change from one to the other unit takes place automatically, but the driver can use the converter E as a brake on long down gradients.

The pinion *h* is in gear with two bevels running loose on the shaft Q, which one they drive in one or the other direction by means of a dog clutch controlled electro-pneumatically.

Two sets of straight gears working in parallel transmit the rotary motion to the jack shaft Q and to the driving wheels, the maximum speed of which is 370 r. p. m.

The auxiliaries such as the compressor and lighting dynamos are driven by 120-H.P. diesel engine.

NEW BOOKS AND PUBLICATIONS.

[385 & 656]

LALONI (N.) and LANDRA (A.). — **Nozioni di diritto, di economia e di statistica dei trasporti**, con speciale riguardo alle rete ferroviaria italiana (**Transport law, economics and statistics**, with special reference to the *Italian State Railway system*). — A volume (8 1/2 × 6 inches), of 228 pages with figures. — 1935, Rome, Casa Editrice « Supergrafica Lolli », Via Brennero, 7.

Messrs. N. LALONI and A. LANDRA have already written a number of valuable books on railway practice; their new book is divided into four parts.

The first three parts deal with communications in general, with special reference to Italian conditions; the fourth part is devoted to the Italian State Railway system.

The authors, in the first part, review the different methods of transport in use throughout the world, including railways, sea and inland navigation, airways, roads, not forgetting the pipe lines in the United States, besides which long-distance transport of gas and electricity can be grouped.

We have before us, therefore, on the one hand the old methods which have proved themselves and have reached or passed their zenith, and on the other the new methods which tend to replace the old ones and at the same time profoundly influence the daily life of mankind.

Formerly the division of traffic between the railways and waterways had been fairly stabilised. This balance was destroyed when the roads, revived by motor transport, pipe lines, and aircraft came into use, and introduced serious competition, the dangers of which the authors point out. To meet this competition, many solutions have been suggested.

Messrs. Laloni and Landra mention the theory of the unrestricted development of the different forms of transport, including the railways, at the present time burdened with various obligations and charges; the reasonable division of the traffic between the various competitors, now under trial in Switzerland; and finally the integral transport policy followed in Germany, according to which traffic of public interest should be monopolised by the State. The State alone is in fact considered able to use the various transport facilities available to the best advantage of the public.

The second part is a classic investigation into the economic principles governing rate making. These principles differ when there is free competition and when there is a monopoly. They are also different according as to whether the working is carried out in accordance with the principle of private economy or of the general economy. In all cases, the law of supply and demand applies and the prices fluctuate between the cost price and the market value of transport.

From the principles referred to, the authors show, according to Pirath, the consequences of the replacement of the railway by other forms of transport, as for example the road motor. This would inevitably lead to making a monopoly of road transport as has been done in the case of the railways, and competition, so much advocated by the public would no longer exist.

Under equal conditions as regards responsibility and taxation, the road motor should only work short-distance traffic so that the theory put forward is not workable in the present state of affairs.

As regards the structure of differential rates on a decreasing scale, the authors rightly point out that this structure favours long-distance transport, whilst keeping up the prices in the short-distance zones, where competition is now especially intense.

The authors query whether this structure still meets present-day needs. Short distances should be favoured equally with the long distances. Similar arguments have led, in Belgium, to certain rates being revised.

One chapter in part 2 is devoted to statistical methodology and to railway statistics.

The third part gives particulars of the legal bases of transport in the international field and in Italian domestic traffic. The authors review the sources of the transport law, especially the Barcelona convention on freedom of transit and communications, and the Geneva convention on the international status of the railways; the Berne conventions and the international conventions on maritime and aeronautical law. In passing, we must refer to the review of the question of the consignment note to order.

The fourth section, as we have already said, is devoted to Italy.

The authors have fully attained their objective, as described in the preface of the book. They have produced a manual giving concisely and clearly a general view of the whole complex transport question, which will form a valuable lead to those endeavouring to get to the bottom of this question, by studying the details scattered in a number of publications.

U. L.

[625. 17 (.42)]

Lt.-Col. H. A. HULL, M. Inst. C. E., District Engineer, Northampton, L. N. W. R. & L. M. S. R., 1918-1933. — **Railway Maintenance Problems.** — A pamphlet (8 3/4 × 5 3/4 inches) of 82 pages, profusely illustrated. — 1936, London; Published by *The Railway Gazette*, 33, Tothill Street, Westminster, S. W. 1. (Price : 5 sh. net.)

As shown by the title of the work, the author gives, in a pamphlet full of teachings, the result of his personal experience in the maintenance of the track, and structures.

He deals in succession with landslides, drainage, foundations, retaining walls and abutments of the various structures; track maintenance, shovel packing, building and miscellaneous work. This work is written in a concise way, and can be read profitably by all permanent-way technicians.

R. D.